The Description of the Ring-dial

It is composed of ~~two~~ two Concentric Circles of Silver or Brass. the outer is the Meridian of our Horizon; ye Inner is ye Equinoctial. the latter, in order to represent the Equator, is made movea[ble] upon two pivots, whereby it is fastened to ye Meridian, so as to be capable to traverse it at right Angles; & when it [is] brought to that Situation, it meets with two Supporters, which prop it, and prevent its going further; when it is brought back to its Rest, it falls into two Notches, cut in the Axis, on purpose for its Reception. If we want to keep that Equator at the Elevation proper for each Horizon, the Meridian must be suspended by a Circle, or Ring which is brought to the Latitude of the place on yt Meridian; for if the Ring of suspension runs ~~at our Zenith~~ on the Meridian divided into Degrees, at the Distance of 49 Degrees from

the Equator, that Ring is at our Zenith: therefor from ye Ring to ye Pole, there will remain but 41 Degrees, since the Pole is at 90 Degrees from ye Equator: consequently ye Equator of this Machine will be then at 41 Degrees of Elevation on ye Horizon; & ye Point of the Pole at 49. These four Arches together exhaust the 180 Degrees of the Horizon, & the Distance of the Pole is always like ye Distance from ye Zenith to the Equator. The Ring, to facilitate all the Displacings wanted for every Horizon, sinks a double fastning in a Groove, which reaches along on the two Spaces of ye Meridian. the piece of Suspension runs thus, at pleasure, as far as, under the northern Pole; and like the Northern or Southern Latitude, regulating ye Position of ye Neighbouring pole, & renders the Ring-dial one universal Instruments. the two Poles are represented by two pivots fastned to ye Meridian Circle, or to the two Notches into which ye Equinoctial-circle is lowered

These two poles, or pivots, representing the poles of the world, support a Bridge which play in them by its Extremities and Crosses diametrically ye Equator, brought to its place to act its part, for the Equator is of no use, when folded in its Box, where it becomes concentric to the Meridian.

The Axis is represented by a long and Narrow Aperture, which riggles along the Middle of the Bridge. The use mo[st] of this Aperture is, to lodge in it a smal[l] piece of Metal, which moves, with a Ho[le] through, called Cursor, & which runni[ng] backwards & forwards under ye Sun, according to the various Declinations where it arrives, from one Day to another, is found exactly between the planet, & a point opposite on the inner Edge of ye Equinoctial; whence it follows, that the Sun, ye Cursor, & ye point opposite in the Equator of the Ring dial, being on the same Lin[e]

W. LEYBOURN 88446

THE DESCRIPTION and USE OF A *Portable Instrument*,

Vulgarly known by the Name of

GUNTER's Quadrant.

By which is perform'd most Propositions in *Astronomy*; as, the Altitude, Azimuth, Right Ascension and Declination of the Sun, &c. also his Rising and Setting, and Amplitude; together with the Hour of the Day or Night, and other Conclusions exemplify'd at large.

To which is added,

The Use of NEPIAR's Bones in *Multiplication*, *Division*, and *Extraction* of *Roots*; also the *Nocturnal*, the *Ring-Dyal*, and GUNTER's *Line*, in many necessary and delightful Conclusions, fitted to the Understanding of all Capacities.

By *WILLIAM LEYBOURN.*

The Third Edition, with the Addition of the Use of GUNTER's Quadrant in taking the Declination of a Plain by the Help of a Horizontal Dial; also, the Use of a two Foot Rule in the Mensuration of Timber, &c.

By *CHARLES LEADBETTER.*

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The USE of a Portable Inſtrument Known by the Name of GUNTER's Quadrant.

SECT. I.

Of the Deſcription thereof.

1. THERE needs no large Deſcription of this Inſtrument; for all Perſons that are capable of the Uſe thereof know, 'tis but the fourth Part of a Circle, and divided in the Limb thereof into 90 Degrees, by equal Diviſions, and number'd 10, 20, 30, 40, *&c.* unto 90; each Degree being ſubdivided into 4 Parts, above the Limb. There is inſerted the twelve Months of the Year, and diſtinguiſhed by capital Letters, *viz.* *J.* or *January*,

 F. for

F. for *February*, *M.* for *March*, &c. and each Month is ſubdivided into 5 Days, more or leſs, according as the Largneſs of the Quadrant will bear; and then above the Days of the Month you have, in the Body of the Quadrant, the Hours and Azimuth Lines, together with Part of the Ecliptick and Horizon; alſo a Quadrant, *&c.* as will be much more obvious and intelligible to the Reader, by Inſpection of the Figure thereof hereunto annexed, then by many Words.

2. And, to make the Quadrant compleat, there muſt be added a Couple of braſs Sights with ſmall Holes therein, fixed to one of the Semidiameters of the Quadrant; alſo a Thread or Silk faſten'd to the Center, with a Bead and Plumet as is uſual: And the making hereof is well known to the Workman, and ſhew'd at large by Mr. *Gunter*. What elſe is neceſſary ſhall be explain'd in its Uſe.

SECT. II.

Of the Circle of Months.

THis Circle of Months is figured with the Letters *J. F. M. A. M.* &c. ſignifying the Months *January*, *February*, *March*, *April*, *May*, &c. each Month being divided unequally, according to the Number of the Days that are contain'd therein, as before is intimated.

1. *And now to find any Day of the Month throughout the Year:* Firſt, ſearch out the Month, and, from the Beginning thereof, account the ſmall Diviſions from one Month to another, each of them for five Days, (unleſs your Quadrant be large, and the Month divided into every Day) and by this Means you eaſily find the Place (or Diviſion) of the Day of the Month deſired, which will be much eaſier by Practice, than can be expreſs'd by Words: And here note, that every 10th Day is diſtinguiſh'd by a longer Line then the reſt; thus, if I lay the Thread (being fixed in the Center) to the 10th Day of *January*,

'twill cut in about 21 Degrees in the Limb of the Quadrant: Now in *June* and *December*, when the Sun has his greateſt North and South Declination, the Diviſions here run cloſe, and ſo the Day of the Month cannot be ſo exactly found, but gueſs'd at, and near enough for moſt Uſes; but in all the other Months of the Year, there needs not the leaſt Scruple in this Particular.

2. *Having the Day of the Month, to find out the Sun's meridian Altitude, or how high he will be at Noon?*

Let the Thread be laid upon the Diviſion call'd (or repreſenting) the Day of the Month, and then that very Degree, which the Thread cuts in the Limb of the Quadrant, is the Sun's meridian Altitude required; ſo the Thread, laid to the 15th Day of *May*, will cut 59 gr. 30 m. in the Quadrant's Limb, which is the Sun's Height that Day at Noon; and if it be laid upon the 18th Day, the meridian Altitude will be found 41 gr. 39 m.

3. *The meridian Altitude being known, to find the Day of the Month, which is the converſe of the former.*

The Thread, being laid upon the meridian Altitude, doth alſo fall upon the Day of the Month: So that if you have any one of them, you have both. So, if the Altitude at Noon be 59 gr. 30 min. (as before) and the Thread being ſet thereunto, it falls upon the 15th of *May*, and the 9th of *July*, and which of theſe two is the true Day, may be diſtinguiſh'd by the Quarter of the Year, or another Day's Obſervation: For, if the Altitude prove greater, the Thread will fall on the 16th Day of *May*, and 8th Day of *July*; or, if it prove leſſer, the Thread will fall on the 14th Day of *May*, and the 10th of *July*; and thus the Doubt is fully determined, and by this we diſcover alſo what Days of the Year are of equal Length, which muſt needs follow by Conſequence, if the meridian Altitudes be equal; and ſo the 4th of *September* and 18th of *March* have the ſame meridian Altitude, and the ſame Length, which is to be underſtood in

in the reſt of the Months, as they ſtand oppoſite in their proper Circles.

4. And here 'tis to be obſerv'd, that this Quadrant is accommodated but to one Latitude, and therefore (in this Caſe) ſerves but for one Place, and ſuch which lye parallel thereunto, *viz.* Eaſt or Weſt from thence, (as, ſuppoſe from the metropolitan City of *London*) thoſe that lye 60 or 70 Miles North from this Parallel, the Sun will be a Degree lower, than appears by the Quadrant at Noon; and the contrary, one Degree higher from the meridian Altitude, to ſuch as live 60 or 70 Miles South from *London*, or ſuch Places that lye parrallel to it; this is to be underſtood if you be regulated by the Day of the Month upon the Quadrant.

5. But if you obſerve the Sun's Altitude juſt at Noon (or a little before, and a little after Noon) by holding the Quadrant in both your Hands, turning your left Hand towards the Sun, ſo that the Beams thereof may paſs through the Holes of the Sights, then, the Plummet hanging at Liberty, the Degrees cut in the Limb by the Thread, is the

Alti-

Altitude deſired in any Place; and the ſame may be done by the Moon and Stars, if you look through the Sights at the Moon or Stars, and obſerve then what Degrees are cut by the Thread in the Limb: So upon the 14th Day of *April*, juſt at Noon, the Sun-Beams paſſing through both the Sights, the Thread will fall upon 51 gr. 35 min. the true meridian Altitude of the Sun in the Latitude of *London*, for which Meridian moſt of the Quadrants are made.

SECT. III.

Of the Hour-Lines on the Quadrant.

1. OBſerve that the Arch, drawn upon the Center of the Quadrant to the Beginning of the Sun's Declination, doth repreſent the Equator, or equinoctial Circle (and is uſually made a Radius or Tangent) of 45 Degrees; but that Arch which is drawn by 23 gr. 30 min. of Declination, and is juſt above the Circle of Months and Days, repreſent the Tropicks of *Capricorn* and

Cancer

Cancer, or the Sun's greateſt Declination both North and South; and thoſe Arch-Lines, which are deſcribed upon the Quadrant between the Equator and the Tropicks, being undivided and number'd at the Equator by 6, 7, 8, 9, 10, 11, 12, and at the Tropicks by 1, 2, 3, 4, 5, 6, 7, 8, thoſe very Lines or Arches are the Hour-Circles.

2. That which is drawn from 12 in the Equator to the Middle of *June*, repreſents the Hour of 12 in the Summer; and thoſe which are drawn with it towards the right Hand, are the Hours of the Day in Summer, and alſo of the Night in Winter: But that Arch which is drawn from 12 in the Equator to the Middle of *December*, repreſents the Hour of 12 in the Winter; and thoſe Arches with it to the left Hand, the reſt of the Hours of the Day in Winter, and Night in Summer; and of both theſe, that which is drawn from 11 to 1, ſerves for 11 in the Forenoon and 1 in the Afternoon; that which is drawn from 10 to 2, ſerves for 10 in the Forenoon and 2 in the Afternoon: The Reaſon is, that the ſame Day the Sun has the ſame Altitude 2 Hours before Noon, as it has 2 Hours after

ter Noon; and the ſame Reaſon is to be underſtood in all the reſt, which is plain and eaſily underſtood, as by the following Propoſitions will clearly appear.

3. *The Day of the Month, or meridian Altitude of the Sun, being given, to find the Place of the Sun in the Ecliptick.*

Let the Thread be laid to the Day of the Month, or to the Sun's Height at Noon, (for the one gives the other) obſerve then where it croſſes the Hour of 12, and ſet the Bead to that Interſection; then move the Thread till the Bead fall on the Ecliptick Circle, (which is known by the Characters of the 12 Signs) and it will fall upon the Sun's Place; and ſo if it were the 15th of *May*, or meridian Altitude 59 gr. 30 min. lay the Thread as aforeſaid, and put the Bead to the Interſection of the Hour of 12, and then move the Thread 'till the Bead fall on the Ecliptick, and it will there touch upon the 4th Degree of *Gemini*, and the ſame of *Sagittary*; alſo the 26th of *Cancer* and the 26th of *Capricorn*; and which of theſe is the Place of the Sun, may appear

appear by the Quarter of the Year, or another Day's Obſervation.

4. *To rectify the Bead for the Hour of the Day,* &c.

Knowing the Day of the Month, place the Thread thereon, and then, ſlipping the Bead to the Meridian or Hour of 12, for the Seaſon of the Year, you are fitted to find the Hour by the Sun; but for the Stars, only lay the Bead upon the Star propoſed. And thus, the Bead being rectify'd, if you do but obſerve the Altitude of the Sun, the Bead will fall on the Hour-Line deſired or ſought, if you bring the Thread to the Altitude: So on the 10th of *April*, having rectify'd the Bead for the Time, you may find the Altitude 36 gr. at the ſame time the Bead falls upon the Hour-Line of 3 and 9; and then I may conclude, 'tis 9 in the Forenoon, or 3 in the Afternoon; and ſo upon the 9th of *April*, the Bead being rectify'd, and the Altitude obſerv'd 3 gr. the Bead will fall between 8 and 9 in the Equator, and between 3 and 4 in the Tropicks; ſo that 'tis half an Hour paſt 8 in the Morning, or half an Hour

Hour paſt 3 in the Afternoon, and here obſerve, if the Sun aſcends, it is be Forenoon; but if the Sun deſcends or falls in Altitude, 'tis Afternoon, as Reaſon itſelf will direct: So again, upon the aforeſaid 10th of *April*, if the Sun's Altitude be 40 gr. you will find the Bead at the ſame time fall half way between the Hour-Lines 9 and 10, or 2 and 3; wherefore it muſt either be half an Hour paſt 9 in the Morning, or half an Hour paſt 2 in the Afternoon, which is moſt eaſily diſtinguiſh'd. And after the ſame Method, if upon the 1ſt of *November* I obſerve as aforeſaid, and find the Bead to fall half way between 8 and 9, and 3 and 4 in the Winter-Hour-Circles; hence I conclude, 'tis half an Hour paſt 8 in the Forenoon, or half an Hour paſt 3 in the Afternoon, *& ſic de cæteris.*

5. *The Place of the Sun in the Ecliptick being known, to find the Day of the Month.*

Lay the Thread and Bead on the Place of the Sun in the Ecliptick, and then move the Thread and Bead to the Hour of 12, and ſo, if the Place of the Sun be 4 gr. of *Gemini*, the Bead being laid to this Degree, and then moved to the

Hour of 12 in Summer, the Thread will fall on the 15th Day of *May*, or the 8th of *July*; or, if it be moved to the Hour of 12 in Winter, the Thread will fall on the 6th of *January* and the 14th of *November*, and which of theſe is the Day of the Month requir'd, the Quarter of the Year will determine.

By this and the third Propoſition, there is two Ways ſhew'd to rectify the Bead by the Place of the Sun, and by the Day of the Month; but the beſt Way is that by the Place of the Sun, for in the other ſome ſmall Difference may ariſe by the Leap-year. There is alſo a third Way by a Table of the Sun's Declination for each Day of the Year, (which Seamen are ſeldom without) and if ſo, the Bead may be ſet thereunto in the Line of Declination.

6. *To know how high the Sun will be, at any Hour of the Day given, throughout the Year.*

The Bead being rectify'd for the Time, by any of the Ways aforeſaid, bring it to the Hour given from the Hour of 12 towards the Line of Declination

nation, and the Degrees, cut by the Thread in the Quadrant or Limb thereof, will ſhew the Altitude of the Sun at that Time; ſo upon the 30th of *March*, at 8 in the Morning and 4 in the Afternoon, the Sun will be found to be 24 gr. 30 min. high: Again, on the 10th of *April*, the Sun being in the Beginning of *Taurus*, the Bead being rectify'd, you ſhall find the Altitude at Noon at *London* 50 gr. 15 min. but at 11 in the Morning 48 gr. 12 min. at 10 of the Clock but 43 gr. 12 min. at 9 only 36 gr. at 8 of the Clock 27 gr. 30 min. at 7 but 18 gr. 18 min. at 6 in the Morning but 9 gr. and at 5 a Clock it touches the Line of Declination, and has no Altitude at all; whence we may conclude, the Sun did riſe much about that Hour. And then, if you move the Thread again from the Line of Declination towards the Hour of 12, you ſhall find the Sun 8 gr. 33 min. below the Horizon at 4 in the Morning, and near 16 gr. at 3, and 21 gr. 51 min. at 2, and 25 gr. 40 min. at 1, and 27 gr. at Midnight. For the Bead being rectify'd as aforeſaid, and brought to the Hour of the Night (which, as before was intimated, are the Winter-Hours

in the Summer, and the Summer-Hours in Winter) then the Thread in the Limb cuts the Degree of the Sun's Depression for any Hour of the Night; and thus 'twill be found, that at a 11 of the Clock at Night, the 30th of *March*, the Sun will be found at least 28 gr. 30 min. below the Horizon.

7. *The Hour of the Night given, to find the Sun's Depression.*

And here let it be observed, that the Sun is always as much below the Horizon at any Hour of the Night, as his opposite Point is above the Horizon at the like Hour of the Day, and therefore (to make this more plain) the Bead being set, if the Question be put for any Hour of the Night in Summer, then move it to the like Hour of the Day in the Winter-Hours: But if of any Hour of the Night in Winter, then move the Bead to the like Hour of the Day in Summer, and so the Degrees, cut by the Thread in the Limb of the Quadrant, shall shew how much the Sun is below the Horizon at that Time: And so suppose it the 10th of *April*, at 4 of the Clock in the

the Morning, the Bead being ſet to his Place, according to the Time in the Summer-Hours, and brought to 4 of the Clock in the Afternoon in the Winter-Hours, you will find the Thread to cut 8 gr. and about 30 min. in the Limb of the Quadrant, which is the true Depreſſion of the Sun at that Time.

8. *The Depreſſion of the Sun ſuppoſed, to give the Hour of the Night with us, or the Hour of the Day to our Antipodes.*

In regard the Sun is as much above the Horizon at all Hours of the Day, as his oppoſite Point is below the Horizon at the like Hours of the Night; therefore, firſt ſet the Bead according to the Time, and then bring the Thread to the Degree of the Sun's Depreſſion below the Horizon, ſo ſhall the Bead fall on the contrary Hour-Lines, and thereby ſhew the Hour of the Night in reſpect of us, which is the like Hour of the Day to our Antipodes: So the 10th of *April*, the Sun being then in the Beginning of *Taurus*, and, by Suppoſition, 8 gr. 30 min. below the Horizon in the Eaſt, it is required to be known, What Time of

the Night it is? Firſt ſet the Bead according to the Day in the Summer-Hours, then bring the Thread to 8 gr. 30 min. in the Limb of the Quadrant, ſo ſhall the Bead fall among the Winter-Hours on the Line of 4 of the Clock in the Afternoon; wherefore to our Antipodes 'tis 4 of the Clock in the Afternoon, and to us 4 in the Morning.

9. *Having the Time of the Year, or the Place of the Sun being known, how by this Quadrant to find the Beginning of Day-break, and End of Twilight.*

There is very little Difference between this Propoſition and the former; for the Day is ſaid to break when the Sun comes to be but 18 gr. below the Horizon in the Eaſt, and Twilight to end when the Sun is 18 gr. below the Horizon in the Weſt; wherefore let the Bead be ſet for the Time, and then bring the Thread to 18 gr. in the Quadrant, ſo ſhall the Bead, falling upon the contrary Hour Lines, there ſhew the Hour of Twilight, as before in the Operation of the laſt Propoſition, and ſo 'twill be found a little more then a Quarter after

3 in

3 in the Morning, for Day-break upon the 10th of *April*; after the ſame Manner upon the 30th of *March*, Day-break will be found to be at 3 of the Clock in the Morning; and if ſo, we may eaſily judge when 'twill be dark at Night, which is ſaid to be as much after 6, as this is before 6, and then we may conclude 'twill be dark at 9 of the Clock at Night, it being then paſt Twilight.

SECT. IV.

Of the Azimuth-Lines.

1. OBſerve that thoſe arching Lines, which are drawn between the Equator and the Tropicks, on that Side of the Quadrant towards the right Hand, or neareſt to the Sights, and are number'd with 10, 20, 30, 40, *&c.* in the Equinoctial, then downwards from the Equator to the Tropicks with 110, 120, 130, *&c.* the uttermoſt towards the left Hand repreſenteth the Meridian; that which is number'd with 10, the tenth Azimuth from the Meridian;

dian ; and that which is number'd with 20, the twentieth ; and ſo of the reſt. Thoſe Lines, which are drawn from the Equator to the left Hand, do ſhew the Azimuth in the Summer ; and thoſe other to the right Hand, do ſhew the ſame in the Winter. The Uſes of them follow.

2. *The Azimuth, the Sun is upon being known, to find the Altitude of the Sun above the Horizon.*

Firſt let the Bead be ſet for the Time, as before is ſhewed, then move the Thread until the Bead fall on the Azimuth ; ſo the Degrees, which the Thread cutteth in the Quadrant, ſhall ſhew the Altitude of the Sun at that Time : Where you are to obſerve, that, in regard the Azimuths are drawn on the right Side of the Quadrant, you are alſo to begin, to number the Degrees of the Sun's Altitude, from the right Hand towards the left, contrary to the Directions of ſome former Propoſitions. Examples will clear this Point : Suppoſe the Time given were the ſecond of *Auguſt*, when the Sun hath but 14 gr. 49 m. of North Declination,

clination, ſet the Bead for the Time, and the Sun's Meridian Altitude, or Height at Noon, will be found 53 gr. 17 min. But when he is 10 gr. from the South, 53 gr. 10 min. when 20 gr. then about 52 gr. 8. min. when 30 gr. then 50 gr. 20 min. when 40 gr. then 47 gr. 28 min. when 50 gr. then 44 gr. 12 min. when 60 gr. then 39 gr. 35 min. when 70 gr. then 33 gr. 50 min. when 80 gr. then 27 gr. when the Sun is in the Eaſt or Weſt 90 gr. from the Meridian, then is the Altitude near 19 gr. 20 min. when 110 gr. then 3 gr. 20 min. and before he cometh to the Azimuth 120 gr. he has no Altitude, for the Sun having 14 gr. 49 min. of North Declination will riſe and ſet at 114 gr. 34 min. Azimuth from the Meridian.

3. *The Altitude of the Sun being given, to find on what Azimuth, or Point of the Compaſs, he bears from us.*

Set the Bead in his proper Place for the Day propoſed (as before directed) and then, obſerving the Sun's Altitude, lay the Thread to the Complement of that Altitude, (which is but accounting

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ſo many Degrees from 90 gr.) on the Quadrant, ſo ſhall the Bead fall upon the true Azimuth required. Example: Suppoſe upon the ſecond of *Auguſt* (having rectify'd the Bead) you obſerve and find the Sun's Altitude to be 19 gr. 20 min. then remove the Thread to the Complement thereof, *viz.* 70 gr. 40 min. or, which is all one, upon 19 gr. 20 min. accounted from 90 gr. from the right Hand to the left, and the Bead will fall upon 90 gr. from the Meridian; and therefore the Point the Sun is upon bears from us, either full Eaſt or full Weſt; and which of theſe it is, may immediately be diſcovered by a ſecond Obſervation; for if the Sun, increaſe in Altitude, 'tis Forenoon, and the Azimuth Eaſt; if the Sun decreaſe in Altitude, 'tis Afternoon, and then the Azimuth is Weſt; which is as eaſily diſcovered, by the Hour of the Day. And ſo again, if I find the Sun's Altitude to be 25 gr. if I lay the Thread to 25 gr. accounted backward from 90 gr. the Bead will fall upon very near 80 gr. from the South, and that is the Point of the Compaſs the Sun is upon Eaſtward, if in the Morning; and Weſtward, if in the Afternoon. By

theſe

theſe Propoſitions you may know the Altitude of the Sun every Hour of the Day, though he appears not; and what Part of the Heavens he is in likewiſe; and, then knowing what Azimuth the Sun beareth from us, you may find not only a Meridian Line, but the Coaſting of a Country, the Situation of a Building, and the Variation of the Compaſs, *&c.* as for Example: Suppoſe ſome Day in the Afternoon, I ſhould find, by the aforeſaid Direction, that the Sun bears from me 60 gr. from the South towards the Weſt, then, there being 90 gr. in each Quarter of the Compaſs, the Weſt will appear to be 30 gr. to the right Hand, the Eaſt is juſt oppoſite to the Weſt, and the Meridian-Line, or North and South, lyes in the midſt between them.

4. *To find the 4 Cardinal Points upon an horizontal Plain.*

Firſt find the Azimuth of the Sun, and inſtantly lay your Quadrant upon the Plain, ſo that the Face thereof may lye uppermoſt, then hold in your Hand ſome ſmall String with a Plummet hanging thereunto, and move the Quadrant till the

the Sun caſteth the Shadow of the String through the Degree of the Limb which was found for the Azimuth, and through the Center of the Quadrant; then, holding the Quadrant ſtill, draw Right-Lines by each Side thereof, and protract them, ſo that they may croſs each other, and theſe Lines ſhall point out Eaſt, Weſt, North, and South.

5. *If two ſeveral Sun-Shadows be obſerved, the one in the Forenoon, and the other in the Afternoon of the ſame Day, exactly to touch with their Ends, the Circumference of the ſame Circle deſcrib'd in a Plain, parallel to the Plain of the Horizon, the Line from the Center, equally dividing the Arch of that Circle betwixt the two Shadows, will be the true Meridian in that Place.*

This is a uſeful Theorem, and may be better underſtood by Example, *viz.* Take a Piece of Board or Mettle, and let it be ſo evenly placed, that it may lye parallel with the Plain of the Horizon; in this Plain deſcribe divers Circles from the ſame Center, and in that Center raiſe a Gnomen at Right-Angles.

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This Platform being thus order'd, let the Shadow of the Gnomen, or Wire, be obſerv'd ſome time before Noon, till ſuch time it do exactly touch the Circumference of one of theſe Circles. Again, in the Afternoon, let the Shadow be obſerved till the End of this Perpendicular touch the Circumference of the ſame Circle, which will exactly happen ſo many Hours after Noon, as the other before Noon; then you are diligently to obſerve theſe two Points in the Arch of the ſaid Circle, and divide that Arch into two equal Parts by a Line from the Center; this very Line is a true meridian Line, upon which when the Shadow falls, you may be ſure 'tis juſt 12 of the Clock, or juſt high Noon.

6. *To find the Declination of a Wall for the making of a declining Dial.*

Apply one Edge of the Quadrant to the Wall, and at the Limb hold up a Thread and Plummet, ſo that the Shadow thereof may paſs through the Center, then, marking what Degree of the Limb the Shadow of the String ſo held

ſhall touch, preſently find the Degree in the Limb of the Sun's Azimuth at that time; then, if you have done right, the Degrees between the Degree of the Azimuth of the Sun, and the Degree of the Shadow of the String ſo mark'd, ſhall be the Degree of the Declination of the Wall from the true Meridian; which, whether it be Eaſtward or Weſtward, may be known by comparing it with the Sun. And note, this Propoſition may be the better perform'd, the farther the Sun is from the Meridian.

7. *To find how much a Plain or Wall declines from the Zenith.*

Apply the Edge of the Quadrant to the Plain or Wall, ſo that the Center may be downwards, and the Limb upwards; then hold a String and Plummet, ſo that the Thread or String may touch the Center and the Limb, and number the Degrees between the Plain and the String, which will ſhew the Quantity in Degrees of the Plain's Reclination

8. *To*

8. *To find the Elevation of the Pole in any Place.*

First take the meridian Altitude of the Sun by Obſervation, (or otherwiſe) and alſo the Sun's Declination (as ſhall be ſhew'd) which if it be Northwards, ſubſtract, if Southwards, add to the Sun's meridian Altitude, and you have the Complement of the Pole's Elevation, or the equinoctial Height; which ſubducted out of 90 gr. leaves the Latitude of the Place deſir'd, which is ſo plain, it needs no Example.

SECT. V.

Of the Ecliptick Circle or Arch.

1. THE Ecliptick is eaſily diſtinguiſhed from the other Circles, and is repreſented by the Arch, to which is annexed the Characters of the 12 Signs, and is drawn from the Hour-Line of 6 in the Equator, to the other ſide of the Quadrant, ending in the Tropicks of

Cancer and *Capricorn*, each Sign being divided unequally into 30gr. which is to be reckon'd both ways from the Characters of the 12 Signs, *Aries*, *Taurus*, *Gemini*, *Cancer Leo*, *Virgo*, *Libra*, *Scorpio*, *Sagittary*, *Capricorn*, *Aquary*, *Pisces*, which Signs do also answer to the 12 Months; and the Thread being laid upon the Day of the Month, and the Bead rectify'd, or brought to the proper Meridian, or 12, as before has been exemplify'd, according to the Season of the Year, *viz.* to the Summer-12 in Summer, and the Winter 12 in Winter, &c. Then bring the Bead to the Ecliptick (so rectify'd) and it will fall upon the Sun's Place therein for that Day, regard being had to the Time of the Year: So upon the 18th of *March*, the Sun's Place, by the falling of the Bead, will be about 8 gr. of *Aries*, and upon the 17th of *October* in 4 gr. 30 m. of *Scorpio*.

2. In finding the Place of the Sun in the Ecliptick, 'tis necessary to know which Way the Sun declines from the Equator; for if he declines North, the Character belonging to his Place is above the Ecliptick, if South, beneath it. Now, for as much as the Bead will fall

fall between two Characters, you may know which it is, by a second Day's Observation; as for Example: Let the 20th of *August* be suppos'd, the Thread being plac'd upon the Day, bring the Bead to the Summer-Meridian, which will shew that the Sun is then in its Northern Declination (because the Bead very plainly shews the same) and the Thread being moved falls either on the 7th gr. of *Virgo*, or at 22 gr. 3 m. of *Aries*, which the Time of the Year will plainly distinguish; for *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*, *Virgo*, are the Northern or Summer-Signs, and *Libra*, *Scorpio*, *Sagittary*, *Capricorn*, *Aquary* and *Pisces*, are the Southern or Winter-Signs: And this Proposition will be found exceeding easy by a little Practice.

3. If the Thread be laid upon the Degree of the Sun's Place in the Ecliptick exactly, it will cut in the Limb of the Quadrant, the Right Ascension of the Sun; so the Sun's Place being 4 gr. of *Gemini*, the Thread laid upon this Degree, will cut 62 gr. in the Limb for the Sun's Right Ascension requir'd: But if the Sun has pass'd about 90 gr. from *Aries*, or more than 3 Signs, then there must be

be more than 90 gr. allow'd to the Right Aſcenſion: Thus, if the Degrees of the Sun's Place be between *Aries* and *Cancer*, then his Right Aſcenſion is the very Degrees cut by the Thread in the Limb; but if the Sun's Place be between *Cancer* and *Libra*, then to the firſt Quadrant you muſt add thoſe Degrees cut by the Thread in the Limb, counting backwards from the Sights-ſide; if between *Libra* and *Capricorn*, then to 180 gr. add what the Thread cuts; if between *Capricorn* and *Aries*, then to 270 gr. add the Degrees cut by the Thread in the Limb, counting backwards again, and you have the Sun's true Right Aſcenſion deſired: So if the Sun be in 26 gr. of *Cancer*, though the Thread falls upon 62 gr. as before, yet the Complement thereunto muſt be added, *viz.* 28 gr. and ſo the Right Aſcenſion will be 118 gr. So upon the 18th of *March*, the Right Aſcenſion is but 7 gr. but upon the 5th of *Auguſt* 145 gr. upon the 10th of *October* 206 gr. and upon the 9th of *March* 360 gr. and thus the Buſineſs of Right Aſcenſion is made as plain as poſſible may be to the meaneſt Capacity. *Uſus promptus facit.*

And

And thus, having the Right Aſcenſion given, you may by the converſe Work find the Sun's Place; for lay but the Thread to the Sun's true Right Aſcenſion in the Limb, and it will croſs the Sun's Place in the Ecliptick deſired.

SECT. VI.

Of the Line of the Sun's Declination.

THE Line of Declination is drawn from the Center to the Beginning of the Quadrant, and divided from the Beginning of *Aries* downwards to 23 gr. 29 min.

Its Uſe is thus, rectify the Bead as before ſhewed, and bring it to the Line of Declination, and you have the Sun's Declination for that Day: So if the Sun's Place given be the 4th gr. of *Gemini*, the Bead firſt ſet to this Place, and then moved to the Line of Declination, will there ſhew it to be 20 gr. 59 min. Declination, Northerly from the Equinoctial; and ſo, if you have only the Day of the Month given, you may preſently

sently find both the Sun's Place, and Declination also for that Day: Thus upon the 17th of *October* the Sun has 13 gr. of Declination South. And note, that if the Bead fall upon the Winter-12, the Declination is South; but if upon the Summer-12, 'tis North; and, having the Declination only given, you may thereby find the Sun's Place, and Day of the Month.

SECT. VII.

Of the Horizon.

1. THE Horizon is represented upon the Quadrant by the Arch drawn from the Beginning of Declination towards the End of *Frebruary*, divided unequally, and number'd by 10, 20, 30, 40, *&c.*

2. *Having the Place of the Sun, or Day of the Month, to find the Amplitude of the Sun's Rising and Setting.*

Let the Bead, rectify'd to the Time given, be brought to the Horizon, and there it ſhall ſhew the Amplitude required: So if the Day of the Month given be the 15th Day of *May*, and the Sun the 4th gr. of *Gemini*, the Bead, rectify'd and brought to the Horizon, ſhall there fall upon 35 gr. 8 min. and this is the Amplitude of the Sun's Riſing from the Eaſt, and Setting from the Weſt; which Amplitude is always North if the Sun be in northern Signs, but when he is in ſouthern Signs, then 'tis always Southward; that is, from the 10th of *March* to the 11th or 12th of *September* North, but all the other half Year, the Amplitude of the Sun is Southerly; and ſo upon the 9th of *April*, the Amplitude will be found juſt 18 gr. Northerly. Underſtand the ſame Method in other Operations.

3. *The Day of the Month, or the Sun's Place given, to find the Sun's Aſcenſional Difference.*

Let the Bead, rectify'd for the Time, be brought to the Horizon, ſo ſhall the

the Degrees, cut by the Thread in the Quadrant, ſhew the Sun's Aſcenſional Difference: So upon the 10th of *May*, the Sun being in the laſt Degree of *Taurus*, or Beginning of *Gemini*, let the Bead be rectify'd and brought to the Horizon, and then the Thread, in the Limb of the Quadrant, ſhall ſhew the Aſcenſional Difference to be 27 gr. 30 min. And ſo upon the 15th of *May*, the Sun being about 4 or 5 gr. of *Gemini*, the Aſcenſional Difference will be found near 29 gr. or rather 28 gr. 50 min. So upon the 9th of *April* the Aſcenſional Difference will be found 15 gr. Now, having this, you may thereby find the Time of the Riſing and Setting of the Sun, (which by ſome of the former Propoſitions may be gueſs'd at) but more accurately thus; if the Aſcenſional Difference be converted into Time, by allowing one Hour for every 15 gr. and 4 min. of an Hour for each Degree, and this will ſhew how long the Sun riſeth before ſix in the Summer (that is, from the 10th of *March* to the 11th or 12th of *September*) and after ſix of the Clock in Winter: So if the Day propos'd be the 15th of *May*, and the Place

of

of the Sun, and Aſcenſional Difference as before, *viz.* 28 gr. 50 min. this converted into Time, make 1 h. and about 55 min. and ſo long did the Sun riſe before ſix, *viz.* at 4 h. and 5 min. in the Morning, and conſequently ſets ſo much after ſix; and in the Winter, ſo much as the Sun riſes after ſix, ſo much it ſets before ſix. Hence the Length of the Day and Night is moſt eaſily obtain'd; for having the ſemidiurnal Arch, or Time from Sun-Riſing to Noon, 'tis but doubling thoſe Hours and Minutes, and you have the Length of the Day; ſo 7 h. 55 min. doubled, is 15 h. 50 min. for the Length of the Day, *May* the 15th, which ſubſtracted out of 24 h. remains 8 h. 10 min. for the Length of of the Night.

Sect. VIII.

Of the Five Stars.

THE Stars that were thought convenient (by the Author) to put upon the Quadrant, are first, *Ala Pegasi*, a Star in the Extremity of the Wing of the *Pegasus*, in regard it wants but 1 min. of Time of the Beginning of *Aries*; and, because 'tis not always to be seen, four more were elected for each Quarter of the Ecliptick; an *Oculus Tauri*, or the *Bull's-Eye*, whose Right Ascension in time is 4 h. 20 m. then of *Cor Leonis*, the Lyon's Heart, whose Right Ascension is 9 h. 54 min. the next of *Arcturus*, whose Right Ascension is 14 h. 3 min. and the last of *Aquila*, or the Vulture's Heart, whose Right Ascension is 19 h. 37 min. These five Stars have all of them northern Declination, and of all others some of these will be seen (if the Air be clear) every Night in the Year. Their Use follows, *viz.*

1. The

1. The Altitude of either of theſe five Stars being known, to find the Hour of the Night. Firſt, put the Bead to the Star which you intend to obſerve, then take his Altitude, and by that find how many Hours he is diſtant from Midnight, either before or after; then from the Right Aſcenſion of the Star, ſubſtract the Right Aſcenſion of the Sun converted into Time, and reſerve the Difference; for this Difference being added to the obſerv'd Hour of the Star from the Meridian, or Midnight, ſhall ſhew how many Hours the Sun is gone from Noon, which is the Hour of the Night.

2. As for Example, *May* 15, ſuppoſe the Sun be in 4 gr. of *Gemini*, and I ſet the Bead to *Arcturus*, and obſerving his Altitude, ſhould find him to be in the Weſt about 52 gr. high, and the Bead to fall on the Hour-Line of 2 Afternoon, the Hour would be 11 h. 50 min. paſt Noon, or but 10 min. ſhort of Midnight: For 62 gr. the Right Aſcenſion of the Sun converted into Time, makes 4 h. 8 min. which if we take out of 14 h. 3 min. the Right Aſcenſion of *Arcturus*, the Difference will be 9 h. 55 min.

and this being added to 2 Hours, the obſerved Diſtance of *Arcturus* from the Meridian, ſhews the Hour of the Night to be 11 h. 55 min. as aforeſaid.

3. Again, to make the Buſineſs more plain, ſuppoſe the 9th of *July*, and the Sun be then in 27 gr. of *Cancer*, I ſhould ſet the Bead upon *Oculus Tauri*; and, obſerving his Altitude, ſhould find him to be in the Eaſt, about 12 gr. high, and the Bead to fall on the Hour-Line of 6 before Noon, which is 18 h. paſt the Meridian, the Hour of the Night would be found ſomewhat more than 15 min. paſt 2 in the Morning, which may be proved thus: The Right Aſcenſion of the Sun is 119 gr. which converted into Time (by allowing 15 gr. for an Hour, and 4 min. for a gr.) it makes 7 h. 56 min. this ſubſtracted out of 4 h. 20 m. the Right Aſcenſion of *Oculus Tauri* (adding the Circle, or 360 gr. that Subſtraction may be made) the Difference will be 20 gr. 24 min. and this being added to 18 h. (which was the obſerv'd Diſtance of the Star from the Meridian) ſhews, that the Sun (abating 24 Hours, or the whole Circle) is 14.

h. 24

h. 24 min. paſt the Meridian, and therefore 24 min. paſt 2 in the Morning.

4. Now, if you have a Nocturnal upon the Backſide of the Quadrant, you need not uſe this Equation of Right Aſcenſion; for, knowing the Time of the Year, when the Star will be South at Midnight, you may bring that Time to the Hour obſerved; then will the Day of the Month, wherein you made your Obſervation, point at the Hour of the Night required.

5. As in the firſt Example, where, on the 15 of *May*, the Bead, ſet to *Arcturus*, fell upon the Hour-Line of 2 Afternoon; becauſe this Star will be in the South the 14th of *October*, compleat at Midnight, you may place the 14th of *October* at the Hour of 2; ſo the 15th of *May* will point to 11 h. 55 min. as before, the Hour of the Night deſired.

6. And in the ſecond Example, of the 9th of *July*, where the Bead, ſet to the *Bull*'s *Eye*, fell on the Hour-Line of 6 before Noon; becauſe the *Bull*'s *Eye* will be in the South the 16th of *May*, compleat at Midnight, you may turn the 16th of *May* to the Hour of 6, and

 thereby

thereby you ſhall find the 9th of *July*, to point unto 2 h. 24 min. as before.

Sect. IX.

Of the Quadrat.

1. THE Quadrat hath two Sides only divided, and the other two Sides, next unto the Center, may be ſuppoſed to be divided, each of them into 100 equal Parts; that which is next to the Horizontal Line, contains the Parts of Right Shadow; the other next to the Sights, the Parts of Contrary Shadow. Its Uſe follows.

2. *Any Point being given, to find whether it be level with the Eye or not*

If you lift up the Center of the Quadrant, ſo as the Thread with the Plummet may play eaſily by the Side of it, and look through the Sights to the Place given, and the Thread fall upon the Line A B, drawn by the Side of the Quadrant (call'd the Horizontal Line)

Line) then is the Place given level with the Eye; but if it fall within the ſaid Line on any of the Diviſions, then it is higher; if without, it muſt needs be lower, than the true Level of the Eye.

3. *To find any Height above the Level of the Eye, or a Diſtance at one Obſervation.*

Look through the Sights to the Place, going nearer or farther from it, till the Thread fall on 100 Parts in the Quadrat, or 45 gr. in the Quadrant; ſo ſhall the Height of the Place, above the Level of the Eye, be equal to the Diſtance 'twixt the Place and the Eye. But if the Thread fall on 50 Parts of Right Shadow, the Height is but half the Diſtance; if it fall on 25, it is a Quarter of the Diſtance; if on 75, 'tis three Quarters of the Diſtance; for as oft as the Thread falls upon the Part of Right Shadow, it holds this Proportion, *viz.*

As 100 *is to the Parts upon which the Thread falls: So is the Diſtance to the Height required.*

And ſo on the contrary,

As the Parts cut by the Thread are to 100: *So is the Height to the Diſtance.*

4. But when the Thread ſhall fall upon the Parts of Contrary Shadow, if it fall on 50 Parts, the Height is double the Diſtance; if on 25, 'tis four Times as much as the Diſtance: For as often as the Thread falleth on the Parts of Contrary Shadow, the Proportion is,

As the Parts cut by the Thread are to 100: *So is the Diſtance unto the Height.*

And the contrary,

As 100 *is unto the Parts cut by the Thread: So is the Height unto the Diſtance.*

And what is here ſaid of Height and Diſtance, the ſame may be underſtood of Height and Shadow.

5. *To find a Height or Diſtance at two Obſervations.*

Suppoſe

Suppose the Place, which is to be measured, could not otherwise be approached, and yet it were required to find the Height and Distance; first, I make choice of a Station where the Thread may fall on 100 Parts in the Quadrat, and 45 gr. in the Quadrant; then shall the Distance from the Object be equal to its Altitude. But if I go farther, in a direct Line with the former Distance, and make choice of a second Station, where the Thread may fall on 50 Parts of Right Shadow, then shall the Distance, from the Object to my Station, be double the Height of the Object: Wherefore, if I measure the Difference between the two Stations, it will be equal both to the first Distance, and the Altitude of the Object. But if I cannot make choice of such Stations, then I take such as I may; as suppose one, where the Thread falls upon 50 Parts of Right Shadow, and the second upon 40, and suppose the Altitude of the Object 100, *&c.* the Proportion holds,

As 50 *Parts are unto* 100, *the Side of the Quadrat: So is* 100, *the supposed Height, unto* 200, *the Distance.*

And,

And,

As 40 *Parts, at the second Station, are unto* 100: *So is* 100, *the supposed Height, unto* 250, *the Distance desired.*

Wherefore the Difference, between the two last Stations, should seem to be 50; and then, if, in the Measuring of it, I find it to be either more or less, the Proportion holds, as from the supposed Difference to the measured Difference; so from Height to Height, and from Distance to Distance: As if the Difference between the two last Stations, being measured, were found to be 30; then say, by the Rule of Proportion, or the Golden Rule,

As 50, *the supposed Difference, is unto* 30, *the true: So is* 100, *the supposed Height, unto* 60, *the true Altitude.*

And,

As 200, *the supposed Distance, is unto* 120, *the true: So is* 150, *at the second Station, unto* 250, *the Distance required.*

6. If

[illegible] [illegible] [illegible]anding upon a known Altitude, and you would thereby know the Diſtance, work as you did before; only that which was then the Parts of Right Shadow, muſt now be the Parts of Contrary Shadow; and that which was then the Parts of Contrary Shadow, muſt now be the Parts of Right Shadow.

SECT. X.

The Deſcription and Uſe of the Nocturnal, which is uſually put upon the Backſide of Gunter's *Quadrant.*

1. ITS an Inſtrument fitted chiefly to know the Hour of the Night by the Stars: It conſiſts of two Parts, the Fixed and the Moveable. The fixed Part, being the outermoſt Circle, is divided into 24 Parts, repreſenting the Hours of the Night; of which ſo many as are neceſſary are inſerted, which are from 4 in the Afternoon till 8 in the Morning: Each Hour is divided into Halves, Quarters, and Half-Quarters, and farther,

ther, according as the Inſtrument will bear. This Part muſt be fixed on the Back of ſome other Inſtrument, or it may be uſed by itſelf.

2. The other Part is moveable on its Center; the outward Circle next the Edge is divided into 365 Parts, repreſenting the Days of the Year; and theſe are divided into Months, which are diſtinguiſhed by Diviſions and Figures, to know every Day, as is uſual, and the Name to each Month. Within this moveable Place, there is inſerted five Conſtellations of thoſe Stars that are next the North Pole; and in ſome a Star of the firſt Magnitude, called *Hircus*; all which (without incumbring the Nocturnal with more) are ſufficient for this Uſe. There is likewiſe a Thread to be added, lying on the Diameter from 12 to 12, which ſerves for a Meridian; to which thoſe that pleaſe may have added a Scale of Declinations, and a Circle divided into 360 gr. for finding the Right Aſcenſion, and Declination of theſe Stars; but that Work may be done with eaſe many other Ways, and is uſually omitted in the Inſtrument.

2. The

2. The Uſe of this Inſtrument is thus: Firſt, learn to know the Stars, which are uſually placed upon this Inſtrument, which is very eaſy from the bare Inſpection of the Nocturnal itſelf, and they are moſt eaſily known in the Heavens: If you turn yourſelf to the North, and there obſerve the ſeven great bright Stars, in the *greater Bear*, called by moſt People *Charles*'s *Wayne*, thoſe four in a ſquare Form are in the Body of the Bear, the three other are in the Bear's Tail: Having found theſe, take notice that the two Stars in the Square, farthermoſt from the Tail of the Bear, do in a ſtreight Line point to another Star almoſt as big as they are (which is in the Tip of the *little Bear*'s Tail) and called the Polar Star, or North Star, and very near, tho' not exactly, in the Pole. Theſe being known, the reſt will be eaſily found out, by bare Inſpection of the Inſtrument.

3. The Stars being known, now for the more certain Finding of the Hour of the Night, it will be neceſſary to find a Meridian, which is a Line, or Arch, conceived to be drawn through or near the North Star, and ſo right over your Head;

Head; and round about by the South, juſt under your Feet, until it meet in the North Star again; or, to ſpake more properly, it is a Circle that paſſes through the North and South Poles, and the Zenith and Nadir of the Place, and divideth the Firmament into the Eaſt and Weſt Hemiſpheres: And to find this Meridian, I have already ſhewn in the Uſe of the Quadrant. One good Way may be, in ſome Garden, or private Place, where you may clearly ſee the Stars, both above and below the Pole, to pitch exactly upright, and at ſome Diſtance, two Poles of a good length; but this muſt be done juſt at Noon, ſo that the Shadow, made (by the Sun at that Time) of them both, may be in a direct Line, which is a true Meridian. This being premiſed:

4. If at any Time of the Night you would find the Hour by the Nocturnal, ſtand by the Southermoſt of your Poles, (before ſet up) bring it in a Right Line with the other, ſo that the Pole by you may hide the other from your Eye; then ſee what Stars are hid from your Eye by theſe two Poles, either above or below the Polar or North Star, which

are

are then upon the Meridian: Then coming to your Nocturnal by the Help of your Thread, bring the moveable Part thereof into the ſame Poſition as you find the Stars in the Firmament, ſetting thoſe upon the Meridian under the Thread, that you find to be hid from your Eye by the two Poles: Then find, in the moveable Part, the Day of the Month of your Obſervation, and juſt againſt it, on the fixed Part, you ſhall find the Hour of the Night.

5. But as it would be a moſt certain Way to have a Meridian for a while to exerciſe, until you are well acquainted with the Operation and Performance; yet you may come very near to the Matter (and near enough for common Uſe) without a Meridian, thus: When you know the Polar Star, place your Body directly upon the Star, and imagining a Line drawn from the Zonith, or Point directly over your Head, through the ſaid Star, and ſo directly down to the Earth, obſerve what Stars, of thoſe that are on your Plate, either over or under the Pole Star, are upon that ſuppoſed Line which is your Meridian; then, coming to your Nocturnal,

place the moveable Part in the same Posture, and just against the Day of the Month, on the moveable Part, is the Hour of the Night.

6. An Example or two will make all plain.

Suppose, upon the first of *August*, in the Year 1731, finding, by either of the former Ways, that the two Stars of *Charles's Wayne*, that are farthest from the Tail of the Bear (which, as I said before, point directly to the Polar Star) are on the Meridian below the Pole; then, coming to my Nocturnal, I bring those Stars under my Thread below the Pole, and then, looking for the Day of the Month *August* 1st, I find that 'tis almost half an Hour past one a Clock in the Morning. And the same Night finding that Star in the Nose of the great Bear, to be on the Meridian below the Pole, I place this under my String in my Nocturnal, and seek the Day of the Month, and against it I find it to be half an Hour past 10 at Night: And so upon *July* the 1*st*, finding the Star *Hircus* (a Star of the first Magnitude) to be on the Meridian below the Pole, I bring my moveable Part to its proper

proper Place, as before directed) and find it to be half an Hour paſt nine a Clock at Night; *et ſic de ceteris. Uſus promptus facit.*

SECT. XI.

Shewing the Uſe of Gunter's *Quadrant, in taking the Declination of a Plane, by help of a Horizonial Dial.*

ON the back Side of the Quadrant, you may draw a Circle, and divide it into four 90 gr. or 360 gr. Draw two Diameters, and to one of them write *Axis* of the Plane, and the other will cut it at the Right Angles in the Center; to the Ends of theſe Diameters, put four Capital Letters, E, W, N, S, to ſignify Eaſt, Weſt, North, South: On the Center of this Circle, let there be a ſmall Pin, about two Tenths of an Inch long, on which a Horizontal Dial is to move; then, having fixt your Quadrant-Edge to the

Plane, whoſe Declination you are ſeeking, you muſt be very careful that it be horizontal, on which ſet your Horizontal Dial, (made for the ſame Latitude) and on the Meridian-Line of of the Dial, let there be a ſmall Tooth, to point at the Degree of the Circle, on the back Side of your Quadrant. Theſe Things being thus prepared, by your Quadrant find the true Hour of the Day, to which Time ſet the Horizontal Dial, that now moves upon the Center of the Circle, on the back of your Quadrant; and at the ſame Time will the Tooth or Index, that iſſueth from the Meridian Line of your Dial, cut the Circle in Degrees of the Planes Declination. This is a very plain and familier Method, of finding the Declination of a Plane, and much eaſier than that found by the Sun's Azimuth, till you be well acquainted with Sphericks.

Here may ſeem ſome Difficulty to the young Tyro, in finding the Hour of the Day, if he has not got an Aſtronomial Quadrant, and well skill'd in Sphericks: But this Obſtacle is ſoon removed by Help of an Univerſal Ring-Dial, ſuch as is deſcribed in this Appendix;

pendix; but then I adviſe it may be about nine Inches Diameter, for that is the beſt Size for this Purpoſe; for if it is any leſs, the Hours will be too ſmall, to diſtinguiſh the Time to that Exactneſs, as is here required; and if the Diameter of the Dial be more, there will be too great a Penumbra attending the Ray of Light, that is caſt upon the Equinoctial; therefore a Dial about nine Inches Diameter, ſeems to be the beſt for this Purpoſe.

SECT. XII.

The Deſcription of the Univerſal Ring-Dial, which ſheweth the Hour of the Day in any Part of the World, and the Latitude alſo.

1. THIS Inſtrument is generally known, and very uſeful for moſt Perſons, and a Pocket Companion. It is projected out of two great

Circles of the Sphere; alſo an Axis, and a little Ring to hang it by; and the Making thereof is well known to the Workman. 2. The greater Circle is the grand Meridian, one Quadrant, or Quarter thereof, is divided into ninety Degrees, to ſet it to the Latitude of the Place wherever you are. On the other Side of the Meridian is a Quadrant of Altitude, to take the Height of the Sun, thereby to find the Latitude of the Place.

The leſſer of theſe two Circles (though both repreſent great Circles of the Sphere) is the Equinoctial, divided into 24 equal Parts, or Hours, with their Halves and Quarters, which are numbred but from three in the Morning, to Nine at night; the reſt of the Hours are left out, being ſeldom or never uſed.

3. The Diameter, or broad Plate, hath a ſlit in the Middle, and upon one Side are the Months and Days of the Year, graduated to every fifth Day; on the other Side is the Sun's Declination, from the Equinoctial to every fifth Day, which is to be uſed with the

Qua-

Quadrant of Altitude, to find the Latitude of the Place. The little Ring is made to ſlide along the Quadrant, with a ſmall Tooth, to ſet it to the Latitude: And the Uſe of this Portable and General Inſtrument is as followeth.

SECT.

SECT. XIII.

The Uſe of the Ring-Dial in ſeveral Examples; firſt to find the Latitude, and ſecondly the Hour of the Day in any Place throughout the habitable World; and therefore an excellent Companion for all Travellers, Gentlemen, or others, of what Degree or Quality ſoever: 'Tis fit they ſhould accommodate themſelves with both this, and the Quadrant; the one being General, the other Particular; and the one ſupplies the Defects of the other.

1. *For the Elevation of the Pole, or the Latitude of the Place.*

FIRST, ſet the Hole in the moving Piece, (or Bride, ſo called by ſome) to the Day of the Month, then turn the other Side, and right againſt the Hole is the Sun's Declination for that

that Day. The ſame Day take the Sun's Meridian Altitude, (which is his Height at Noon every Day) and may be performed by this Inſtrument, thus: Put a Pin into the Hole, which you ſhall find in the greateſt Circle; then move the Tooth to the beginning of the Degrees in the leſſer Quadrant, and turn the Pin next to the Sun, and that Degree which is cut by the Shadow of the Pin, is the Sun's Altitude, (which muſt be taken juſt at Noon, as aforeſaid.)

2. If the Time of your Obſervation be from the 10th of *March*, to the 13th of *September*, you muſt ſubſtract the Declination out of the Meridian Altitude of the Sun; but from the 13th of *September*, to the 10th of *March*, add, and the Sum, or Difference ſhall be the Complement of the Latitude, or Equinoctial Height, which being ſubducted out of 90 gr. leaves the Latitude of the Place.

Example I.

1. Suppoſe the Latitude was unknown, and upon the 11th Day of *June*; you deſire to find it then, by the

the former Rule, find the Sun's Declination for that Day, which will be 23 gr. and 29 min. (or the Sun's greatest Northern Declination; then take the Sun's Altitude, juſt at 12 of the Clock, which at, and near *London*, will be found 61 gr. 57 m. then ſubſtract the Sun's Declination, 23 gr. 29 m. out of 61 gr. 57 m. and the Remainder will be 38 gr. 28 min. the Complement of the Latitude or Equinoctial Height, which ſubducted from 90 gr. leaves 51 gr. 32 m. for the Latitude of *London*.

Example II.

2. As the former Directions ſhew how to obſerve the Latitude, the longeſt Day in the Year, when the Sun has his greateſt Northern Declination; ſo here admit, that on the 10th of *December*, when the Sun's greateſt Southern Declination is alſo 23 gr. 29 min. And the Meridian Altitude, but 14 gr. 59 m. add theſe two Numbers together, and they make 38 gr. 28 m. which deducted from 90 gr. leaves the Latitude as before.

2. *To find the Hour of the Day.* You muſt ſet the Tooth or Index, to the Height of the Pole, or Latitude of the

the Place, and ſlide the Hole in the Plate to the Day of the Month; then draw out the Equinoctial, or leſſer Circle, and as near as you can gueſs at the Hour, and turn the Hole to it; then hold the Inſtrument by the little Ring, and move it till the Sun ſhine through the Hole, upon the middle Line in the Equinoctial, and that is the true Hour of the Day deſired; and the Meridian, as it hangeth, lies in the Meridian of the World, truly North and South.

AN APPENDIX.

The Uſe of Gunter's *Line in meaſuring Board and Timber.*

1. *ADmit a Board be* 10 *Inches broad, and* 20 *Foot long, I demand the Content.*

Set one Foot of the Compaſſes in 12, and extend the other to 10; then ſet one Foot in 20, and extend the other back-

backwards, and it will fall in 16 Foot and a half, which is the Content of the Board required.

2. *Admit a Board be 15 Inches broad, and 27 Foot long, I demand the Content.*

Set one Foot in 12, and extend the other to 15; then ſet one Foot in 27, and extend the other forwards, and it will fall in 34 Foot which is the Content requir'd.

3. *Admit a Board to be 7 Inches and a half broad, and 29 Foot long, I demand the Content.*

Set one Foot in 12, and extend the other to $7\frac{1}{2}$; then ſet one Foot in 29, and extend the other backwards, and it will fall in 18 Foot, the Content required.

4. *Admit a Board to be 27 Inches broad, and 9 Foot and a half long, I demand the Content.*

Set one Foot in 12, and extend the other to 27; then ſet one Foot in $9\frac{1}{2}$, and extend the other forwards, and it will fall in 21 and a Quarter, which is the Content deſired.

5. *Admit a Piece of Timber to be 18 Inches ſquare, and 20 Foot long, I deſire to*

to know how many ſquare Feet there is contained in this Piece of Timber.

Set one Foot in 12, and extend the other to 8, then ſet one Foot in 20, and extend that Diſtance twice backward, and it will fall in 8 Foot 3 Quarters, which is the true Content required.

6. *Admit a Piece of Timber to be 9 Inches and ½ Square, and 27 Foot long, I demand the Content.*

Set one Foot in 12, and extend the other to 9 ½, then ſet one Foot in 27, and extend that Diſtance twice backward, and it will be in 17 Foot, the true Content required.

7. *Admit a Piece of Timber to be 18 Inches ſquare, and 9 Foot long, I demand the Content.*

Set on Foot of the Compaſſes in 12, and extend the other to 18, then ſet one Foot in 9, and extend that Diſtance twice forward, and it will fall in 20 Foot and ½, the Content deſired.

8. *Admit a Piece of Timber to be 22 Inches ſquare, and 35 Foot long, I demand the Content.*

Set one Foot in 12, and extend the other to 22, then ſet one Foot in 35, and extend that Diſtance of the Com-

paſſes twice forward, and it will fall in 118 Foot, which is the Content required.

9. *Admit I have the Breadth of a Board in Inches, to find how much in Length will make a Foot ſuperficial.*

Extend the Compaſſes from the Breadth to 12, the ſame will reach from 12 to the Content forward, if the Breadth be leſs then 12, and backward if the contrary.

SECT. II.

Shewing the Uſe of the Carpenters Two-Foot-Rule, in the Menſuration of Board and Timber, &c.

BECAUSE croſs Multiplication is better underſtood, and conſequently imbraced by the common Artificers, than Decimal Arithmetick, I ſhall here ſubjoin a Table with Directions, for inſtructing thoſe unacquainted with it, which is this:

Croſs

Cross Multiplication-Table.

Factors	Feet	Inches	Parts	Seconds
Feet	Feet	Inches by 12	Parts by 12	Seconds by 12
Inches	Inches by 12	Parts by 12	Seconds by 12	Thirds by 12
Parts	Parts by 12	Seconds by 12	Thirds by 12	Fourths by 12
Seconds	Seconds by 12	Thirds by 12	Fourths by 12	Fifths by 12

Explanation.

1. Feet multiplied by Feet produce Feet.

2. Feet by Inches produce Inches, which divided by 12 give Feet.

3. Feet multiplied by Parts of an Inch, and divided by 12, are Inches.

4. Inches multiplied by Feet, and divided by 12, are Feet.

5. Inches multiplied by Inches, and that Product divided by 12, give Inches.

6. Inches multiplied by Parts produce Seconds, (or a Quantity less than the

the Part of an Inch) which divided by 12 give Parts of an Inch.

7. Parts of an Inch multiplied by Feet, and divided by 12, give Inches.

8. Parts of an Inch, multiplied by Inches, and divided by 12, gives in the Quotient Parts of an Inch, and ſo on, as the Table expreſſeth, to Seconds, which are a Quantity 12 Times leſs, than the Parts of an Inch; as for Example: Let it be required to

	F.	I.	P.	
Multiply	5	3	6	
By	2	4	6	

Operation.

	F.	I.	P.	S.
	10	0	0	
	0	6	0	
	0	1	0	
	1	8	0	
	0	1	0	
	0	0	2	
	0	2	6	
	0	0	1	6
	0	0	0	3
Product.	12	6	9	9

Note. In adding the ſeveral Parts together, you muſt carry 12 in all the Denominations. *Exam-*

Example 2. Multiply me 7 Feet, 8 Inches, by 9 Inches, and 3 Parts.

Operation.

	F.	I.	P.
	7	8	0
	0	9	3
	5	3	0
	0	6	0
	0	1	9
	0	0	2
Product.	5	10	11

Example 3.

	F.	I.	P.	
Multiply me	0	11	9	
By	0	5	0	
	0	4	7	S.
	0	0	3	9
Product.	0	4	10	9

Exam. 4. performed Duodecimally

				F.	I.	P.	S.
Multiply me				9	10	3	9
By				8	11	9	6
			4	11	1	10	6
		7	4	8	9	9	
	9	0	5	5	3		
	78	10	6	0			
Product.	88	6	9	1	2	7	5

Note. You must begin with this Example at the right Hand, and carry the 12, as you do the tens in common Multiplication, and say 6 Times 9 is 54, that is 6 and carry 4 Twelves; then 6 times 3 is 18, and 4 I carried is 22, that is ten above 12, and carry 1 Twelve; then 8 times 10 is 80, and 1 I carry'd is 81, that is 1 and carry 6 Twelves; then 6 times 9 is 54, and 5 I carry'd is 59, that is 4 Feet and 11 Inches to set down, as you see in the Example: Then you must go on just thus with every one of the other Multipliers, which done, you must add the four several Products together, by carrying the 12, and then I find the Product to be 88 Feet, 6 Inches, 9 Parts (to $\frac{3}{4}$ of an Inch) 1 Second, 2 Thirds, 7 Fourths, and

6

6 Fifths, which is the exact Product of

	F.	I.	P.	S.
	9	10	3	9
Multiply by	8	11	9	6

The like is to be obſerv'd of any other Feet and Inches whaſotever.

Being thus prepared with Duodecimal Arithmetick, commonly called Croſs-Multiplication, you muſt in the next Place underſtand the Artificers common Two-Foot-Rule, which I thus deſcribe. This Rule is made of dry Boxwood, two Foot long, with a ſtrong Braſs-Joint, to fold up to a Foot, for the Conveniency of the Pocket, on which there is a Line of Inches, numbred from one End to the other with Figures, 1, 2, 3, 4, *&c.* to 24; and each Inch is divided into 8 equal Parts, or half Quarters of an Inch; under this Line of Inches is placed the Line of Board-Meaſure, with the Table at the End, which is to ſhew how much in Length and Breadth will make a ſuperficial Foot; and this Line is thus made, *viz.* As the Length or Breadth of the Board is to 1; ſo is 144 to the other; that is, If a Board be 8 Inches broad, how much in Length will make a Foot of that Board? *Opera-*

Operation.

As 8 : 1 :: 144 : 18. So 18 Inches in Length, and 8 in Breadth, is juſt one Foot of Board. So likewiſe, if the Breadth of a Board be 6 Inches, the Length to make a Foot; muſt be 24 Inches, or 2 Foot, and if the Breadth of the Board be 7 Inches, the Length of that, to make a Foot, muſt be 1 Foot, 8 Inches, and 6 Tenths of an Inch; but if the Breadth be only 5 Inches, then the Length of the Board, to make a Foot, muſt be 2 Feet, 4 Inches, and 8 Tenths of an Inch: As this Table, which is on one End of the Rule, more fully ſheweth.

A Table of Board-Meaſure.

Inches	1	2	3	4	5	6	7	8
Feet	12	6	4	3	2	2	1	1
Inches	0	0	0	0	4.8	0	8.6	6

But when the Breadth of the Board exceeds the Table at the End of the Rule, then find it along the Side, and, right againſt the Inches of the Breadth, you will find, in the Line of the Board-Meaſure,

Meaſure, the Inches in Length of that Board, that will make a Foot; as, Suppoſe the Breadth of the Board be 10 Inches, what Length will make a Foot? Look for 10 Inch. in the Line of Inches, and right againſt, it in the Board-Meaſure Line, you will find 14 Inches, and 4 Tenths of an Inch, and ſo much in Length will make a Foot. Thus have I given you, the full Explanation of the Line of Board-Meaſure, and now I ſhall ſhew you its Uſe; how expeditiouſly to meaſure any Board, which is perform'd thus: Take the Rule in your Hand, and meaſure the Breadth of this Board, which I will here ſuppoſe to be 11 Inches, then look on your Board-Line, and ſee how much in Length, and that Breadth, will require to make a Foot, which you will find there to be 13 Inches, and one Tenth Part of an Inch. Lay your Finger at 13 Inches, and begin at the End of the Board, and meaſure along the Side, till you come to the other End; then, as often as you find 13.1 Inches, in the Length of the Board, ſo many Feet of Board is contained therein.

Exam-

Example 2. Suppoſe you meaſure with the Two-Foot-Rule, and find the Breadth of a Board, *&c.* to be 23 Inches, and look upon the Board-Meaſure Line, and find the Breadth of that Board that will make a Foot, which is $6\frac{1}{4}$ Inches; here hold your Finger, or mark it with Chalk; then begin at the End, and meaſure along the Board, and as often as you find $6\frac{1}{4}$ in the Length, ſo many Feet doth that Board contain.

If your Board to be meaſured be more than 24 Inches broad, ſo that you cannot ſee upon the Line of Board-Meaſure, how many Inches in Length goes to make a Foot of that Breadth; I ſay, in this Caſe, you muſt have recourſe to the Proportion, made uſe of in making the Line above given, and then proceed to meaſure the Board as before. *Example:* There is a Table, whoſe Breadth is 27 Inches, and Length 7 Foot, how many Feet of Board doth it contain?

Firſt find how much of that Breadth will make a Foot, thus,

As 27 : 12 :: 12 : 5.33. Or, as 27 : 1 :: 144 : 5.33. Here you ſee, that

5.33

5.33 Inches in Breadth, and 27 in Length is a Foot. Mark your Rule with Chalk at 5.33, and meaſure along the Side of the Table, and you will find it to contain 15 Feet, and almoſt three Quarters of a Foot.

The common Artificers Rule is now much improved, by adding a Slider in one of the Legs, which, if they do but take the Pains to underſtand, will much facilitate the Work of Meaſuring Superficies and Solids; and, for the ſake of thoſe that are unacquainted with it, I ſhall here give them, to underſtand, that the Lines, upon thoſe Sliding-Rules, were the Invention of Mr. *Edmund Gunter*, and ſo are known, by the Name of the *Line of Numbers*, or *Gunter*'s Line, being at firſt deduced from the Logarithms, which are compoſed of a ſingle and double Radius, to ſlide by each other. The Radius is Divided into nine unequal Parts, in a Geometrical Proportion, and figured, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, called Primes.

Theſe Diviſions are again divided into 10 like Parts, called Tenths, and thoſe again divided (where the firſt Di-

Divifions are large) into five like Parts called Centifms. And the Figure, at the beginning of the Rule, towards the left Hand, may be either .1, 1, 10, 100, or 1000, then will the fame Figure, in the Middle of the Rule, (when a double Radius) be 1, 10, 100, 1000, or 10000, and at the End, to the right Hand, 10, 100, 1000, 10000, or 100000, encreafing in a tenfold Proportion; which, being well underftood, will give you the full Numeration upon the Rule. The next thing to be known is, how to multiply upon the Rule, which is thus perform'd: Set 1 upon the Slider to the Multiplicand upon the Stock, and againft the Multiplier upon the Slider, is the Product upon the Stock. Or, you may take 1 upon the Stock, and the Multiplicand upon the Slider, and it will produce the fame Thing.

Example. Let it be required to multiply 2 Feet, and a Quarter, by 5 Feet and a Half.

Operation.

Set 1 upon the Slider to 5.5 upon the Stock, (or to 2.25, it matters not

not which) and againſt 2.25 on the Slider, is 12.375, that is, 12 Feet and a Quarter, and half a Quarter of a Foot.

Other Examples.

				Products.
Multiply me	7.3	by	20.2	147.5
	5.7		13.5	77
	9.4		7.6	71.4

Diviſion on the Sliding-Rule.

The Rule.

SET 1 on the Slider, to the Diviſor on the Stock-Piece, and againſt the Dividend on the Stock-Piece, is the Quotient on the Slider.

Example. Let it be required to divide 12.375 by 2.25.

Operation.

Set 1 on the Slider, to 2.25 on the Stock-Piece, and againſt the Dividend 12.375 on the Stock, is 5.5 on the Slider.

Other Examples.

$$\text{Divide me}\left\{\begin{matrix}147.5\\77\\71.4\end{matrix}\right\}\text{by}\left\{\begin{matrix}7.3\\5.7\\9.4\end{matrix}\right\}\left\{\begin{matrix}20.2\\13.5\\7.6\end{matrix}\right\}\text{Qu.}$$

Three Numbers given, to find a fourth in a Direct Proportion.

The Rule.

As the firſt Term upon the Slider, is to the ſecond on the Stock; ſo is the third upon the Slider, to the fourth on the Stock.

Examp. If 10 Foot of Board coſt 15*s.* what will 50 Feet coſt at that Rate?

Operation.

Set 10 upon the Slider, to 15 on the Stock-Piece, and againſt 50 on the Slider, is 75 on the Stock, that is, 3 *l.* 15*s.* the Price of the 50 Feet of Board.

Three Numbers given, to find a fourth in a Reciprocal or Inverted Proportion.

The Rule.

As the third Term upon the Slider, is to the firſt upon the Stock; ſo is the ſecond upon the Slider, to the fourth upon the Stock Piece.

Exam-

Example. If 6 Men can build a Wall in 9 Days, what Time will 3 Men be in doing the ſame.

Operation.

As 3 upon the Slider, is to 6 on the Stock; ſo is nine on the Slider, to 18 on the Stock; and that Time 3 Men will require to finiſh the ſame Work.

To meaſure Board, or Glaſs, &c. on the Sliding-Rule.

AS the Length or Breadth in Inches, is to 144; ſo is the Length or Breadth in Inches, to the Content in Feet.

Example. Suppoſe a Board or Pane of Glaſs be 16 $\frac{1}{2}$ Broad, and 32 $\frac{1}{2}$ long, how many ſuperficial Feet doth it contain.

Operation.

Set 16 $\frac{1}{2}$ on the Slider, to 144 on the Stock-Piece, and againſt 32 $\frac{1}{2}$ on the Stock, is 3 Feet and 7 Tenths of a Foot upon the Slider, the Anſwer ſought.

 Hav-

Having the Length and Breadth of any oblong Superficies in Feet, to find the Content in Feet.

This is no more, than to multiply the Length in Feet by the Breadth in Feet, and you will have the Content in Feet.

Example. Suppose the Breadth of a Board or Glass be 2 $\frac{1}{2}$, and the Length 17 $\frac{3}{4}$, how many Feet doth it contain?

As 1 : 2.5 :: 17.75 : 44.375, that is, 44 Feet, and a Quarter and Half of a Foot, the Content.

Secondly, for Timber.

There is a Line upon the Artificer's Two-Foot-Rule, called the Timber Measure; the making of this Line is thus: As the Square of the Side, of any Piece of Timber or Stone, is to 1; so is the Cube of 12, *viz.* 1728, to the Length in Inches, that will make a Foot solid.

Example. Let the Side of a square Piece of Timber or Stone be 3 $\frac{1}{2}$ Inches, how many Inches in Length will make a solid Foot?

Ope-

Operation.

First ſquare 3 $\frac{1}{2}$ which is 12.25; then ſay, As 12.25 : 1 :: 1728 : 14.1, that is, 14 Feet, and one Tenth of a Foot, that Side will require to make a ſolid Foot. And after the ſame manner is the Line of Timber-Meaſure upon the Rule made.

The Uſe of the Line of Timber-Meaſure is this.

Suppoſe a Piece of Timber or Stone be 17 Inches ſquare, at both Ends throughout, and 10 Feet long, how many ſolid Feet doth it contain? Look on the Line for Timber-Meaſure, and find how many Inches in Length will make a ſolid Foot, which you will find to be 5.97 Inches, which note; then begin at the End of the Timber, and meaſure along; for as often as you find 5.97 in the Length, ſo many Feet of Timber will you find contain'd therein, which in this Example is 20 Feet, and $\frac{10}{144}$ Parts of a Foot.

By the Sliding-Rule, two Operations at once ſetting the Rule.

Say, As 12 is to the Side of the Square 17; ſo is 10 Feet the Length, to a fourth

Number 14.1. Then, without ſtiring the Slider, ſay, As 12 is to 17; ſo is the fourth Number 14.1, to the Content in Feet, $20\frac{10}{144}$.

Example. 2. In round Timber, it is the common Way, uſed amongſt Artificers, to girt the Tree, and to take $\frac{1}{4}$ of that Girt for the Side of the Square; which let be 7 Inches, and the Length 20 Feet, what is the Content?

Operations.

As 12 : 7 :: 20 : 11.6.

Now ſay, As 12 7 :: 11.6 : 6.76 Feet.

Example. 3. Let the Side-Square be $8\frac{1}{2}$, and the Length 30 Feet, how many Feet is contain'd in this?

Operation.

As 12 : 8.5 :: 30 : 21.25

Now ſay, As 12 : 8.5 :: 21.25 : 15 Feet.

Alſo, let the Side-Square be 14, and the Length 36 Feet: Then,

As

As 12 : 14 :: 36 : 42.

Now ſay, As 12 : 14 :: 42 : 49 Feet.

Timber may be meaſured yet more expeditiouſly, than by what I have given above; for if your Rule has the Girt-Line on it, you may find the Content at one Operation. Now the Girt-Line is nothing elſe, but a ſingle Line of Numbers, made to ſlide by the Side of a double Line of Numbers, and begins at 4, and continued to 40; this contains juſt one Radius of the Line, which anſwers to a double Line of Numbers; and the Reaſon of the Line being thus diſpoſed, is becauſe 40 Girt-Feet of Timber is a Load ſquare. This known, girt your Timber about the Middle, a fourth Part of which is the Side of the Square; then meaſure the Tree in Feet, and ſay, As 12 on the Girt-Line, is to the Length in Feet on the Line of Numbers; ſo is $\frac{1}{4}$ of the Circumference on the Girt-Line, to the Content in Feet upon the Line of Numbers.

Example. Let the Circumference of a Tree be 100, one fourth of that

is

is 25 Inches, and the Length 12 Feet, how many ſolid Feet are there in this Timber?

Operation.

Leng. □ *Con.*
As 12 : 12 :: 25 : 52 Feet.

Another Example.

Leng. □ *Con.*
As 12 : 16 :: 20 : 44.4 Feet.

Example 3.

Leng. □ *Con.*
As 12 : 17.5 :: 17.5 : 37.2 Feet.

N. B. But if it happen, that when 12 on the Girt-Line is ſet to the Length of the Tree, on the Line of Numbers, that then $\frac{1}{4}$ of the Circumfe-rence fall off the Line, to remedy this, there muſt be a new Gauge-Point found, to ſupply the old Gauge-Point 12, which is thus performed, *viz.* Set Unity on the Line of Numbers, to 12 on the Girt-Line, and againſt Unity on the Line of Numbers, you'll have the new Gauge-Point 37.95 on the Girt-Line, with

with which work, as has been taught above with the Gauge-Point 12, and you'll have the true Content.

Example. Let the fourth Part of the Girt be 17.5 (as in the laſt Queſtion) and the Length 17.5 Feet, what is the Content, by the new Gauge Point on the Girt-Line?

Operation.

Ga. Point. *Leng.* □
As 37.95 : 17.5 :: 17.5 : 37.2 Feet.

More Examples.

G. P. *Leng.* □
As 37.95 : 10.25 :: 13 : 12.1 Feet.

G. P. *Leng.* □
As 37.95 : 22 :: 9 : 12.3 Feet.

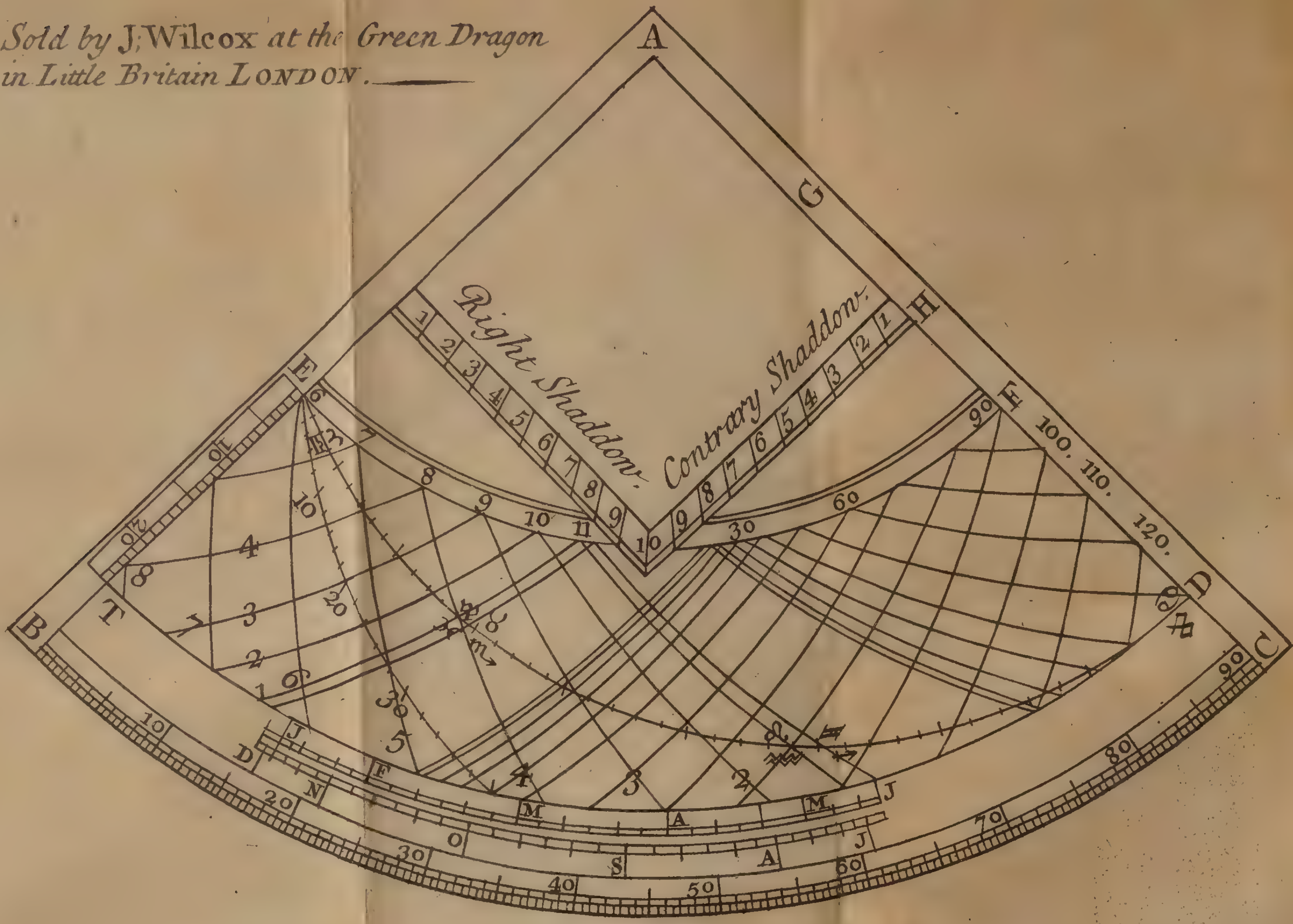
G. P. *Leng.* □
As 37.95 : 18 :: 11.5 : 16.5 : Feet.

G. P. *Leng.* □
As 37.95 : 48 :: 14.75 : 72.8 Feet.

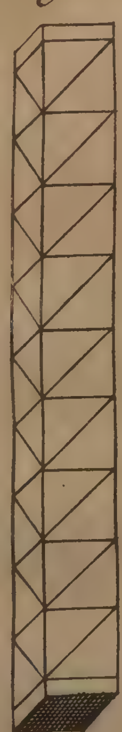
G. P. *Leng.* □
As 37.95 : 33.5 :: 20.25 : 96 Feet.

THE

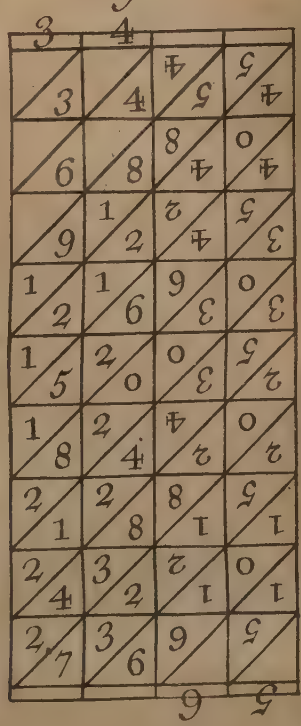
Sold by J. Wilcox at the Green Dragon in Little Britain LONDON.



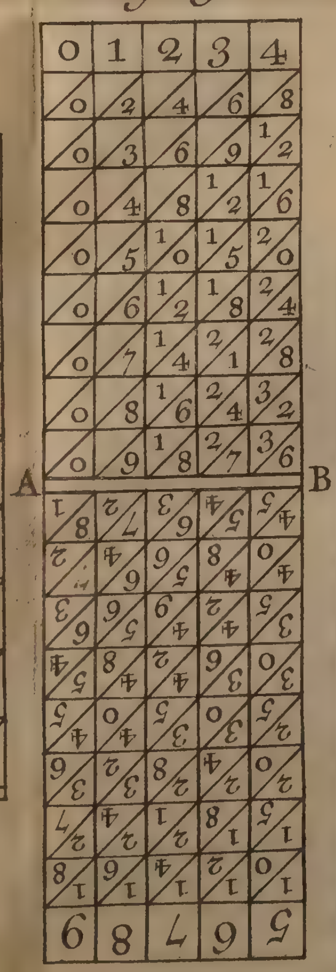
Fig;1.



Fig;2.

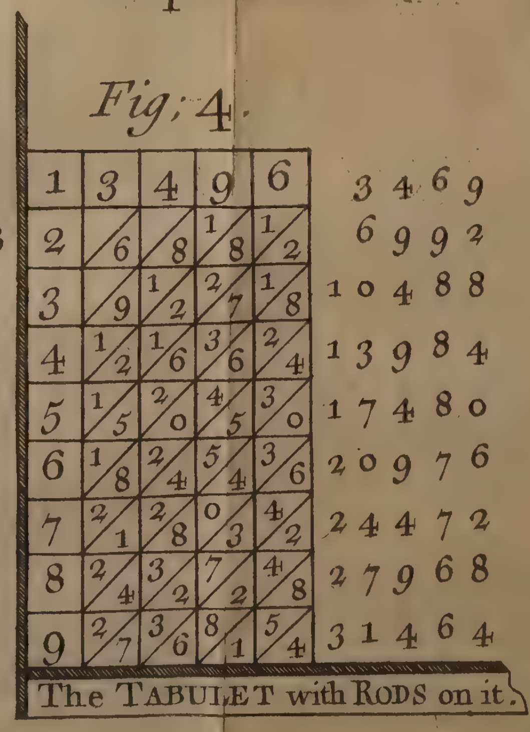


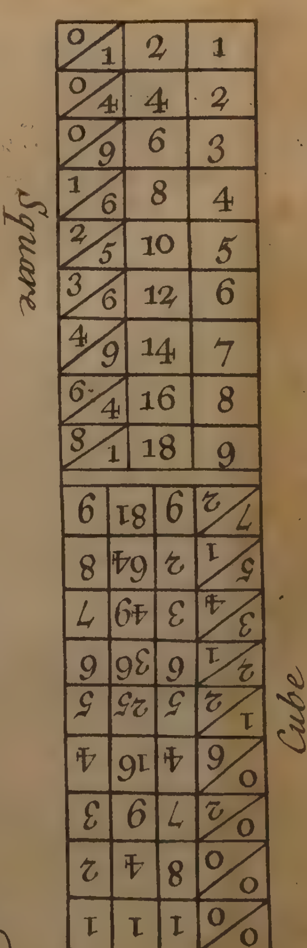
Fig;3.



Place this Figure before Nepair's Bones.

Fig;4.





R.W. Seale Sculp.

THE

Art of Numbring

BY

SPEAKING-RODS,

Vulgarly termed

NEPIER's BONES,

By which

The moſt difficult Parts

OF

ARITHMETICK,

AS,

Multiplication, *Diviſion*, and *Extracting of Roots*, both Square and Cube, are performed with incredible Celerity and Exactneſs (without any Charge to the Memory) by *Addition* and *Subſtraction* only.

Publiſh'd by *W. L.*

LONDON: *Printed for* J. WILCOX, *at the* Green-Dragon, *in* Little-Britain, MDCCXXXII.

THE

ARGUMENT

TO THE

READER.

THE *Right Honourable* John *Lord* Nepeir, *Baron of* Merchiston *in* Scotland, *in the Composure of those ever to be admired* Tables *of his Invention, called* Logarithms, *finding his Calculations so laborious in long and tedious Multiplications, Divisions, and Extracting of Roots, that his Invention to him must needs render itself very unpleasant, had he not known that the Labour when finished would crown both Him and his Work. He advised with divers learned Men, studious*

in

in the Sciences Mathematical, and to them (and amongst them) especially to Mr. Henry Briggs, *who (by a learned and able Divine) was styled (and not without due Respect) our* English Archimedes, *to him, I say, this honourable Lord imparted his* Invention, *who joyning Issue with him, in this* Herculean Labour, *brought them to that Perfection to which they are now (to the Admiration of all* Europe) *arrived.*

In the tedious Calculation of these Numbers, the Author finding his Work to go on but very slowly, at length, studying out for some Help by Art, to assist him in this his noble Enterprize, thinking upon several Helps, at last (by the Blessing of God) he hapned to find out this, which I here intend to describe and shew the Use of, with some Additions and Variation form what he has himself done, in his Treatise *in* Latin, *published and printed at* Edinburgh *in* Scotland,

land, Anno 1617, *entitled*, Rabdologiæ ſeu Numerationes per Virgulas. *The Uſes whereof I ſhall, in the following* Tractate, *endeavour to render ſo plain and eaſy, that he, that can but Add and Subſtract, ſhall be made able, in a Day's Time and leſs, to Multiply and Divide any great Numbers, nay, and to Extract both the Square and Cube Roots.*

I have begun this Treatiſe *with the* Fabrick *and* Inſcription *of theſe* Rods, *according to the* Author's *Deſcription, which being not ſo convenient, either for Portability or Practice, as ſome others which I have ſeen and uſed, I have deſcribed them (I think) in the beſt Manner they poſſibly can be contrived.*

For their Uſe, I am ſure I have done more than hitherto I have ſeen done, and (if I miſtake not) to as good and effectual Purpoſe. I do not publiſh it as a Novelty, neither do I attribute much in it to myſelf beſides

the Method; for, had I not been desired, I should hardly have thought upon it: However, it being done, accept it and use it, till I direct something else to thee, which may be more acceptable, till when, I bid thee heartily

Farewel.

CHAP.

CHAP. I.

Concerning the *Fabrick* and *Inſcription* Of theſe RODS.

IN the foregoing Argument I told you, that the Author and Inventor of this kind of Inſtrument, of which I intend to ſhew the Uſe, called it *Rabdologia*, and the Word he thus defines,

Rabdologia eſt Ars computandi per Virgulas numeratrices: That is, *Rabdologia* is the Art of Counting by numbring Rods.

I. *Of the Fabrick of these Rods, according to the Inventor's Description of them.*

These Rods may be made either of Silver, Brass, Box, Ebony, or Ivory, of which last Substance, I suppose, they were at first made, for that they are (for the most part) by all that know, or use them, called *Nepeir*'s *Bones.*

But let the Matter of which they are made be what it will, their Form (according to this Description) is exactly a square Parallelepipedon, the Length being about three Inches, and the Breadth of them about one tenth Part of the Length. But the Length of these Rods are not confined to three Inches, but let the Length be what it will, the Breadth must be a tenth Part thereof; but that may be accounted a competent Breadth, that is capable of receiving two numerical Figures, for there is never upon one Rod required more to be set on the Breadth thereof.

The Breadth of these Rods, being exactly one tenth Part of the Length thereof, when 10 of these are laid together, they do exactly make a Geometrical

metrical Square, and if 20 of them be tabulated or laid together, they will make a right-angled Parallelogram, whoſe Length is double to its Breadth; if 30 be tabulated, the Figure will be ſtill a Parallelogram, whoſe Length will be three Times the Breadth; and ſo if 40, four times the Length, *& ſic. &c.*

The Rods being thus prepared of exact Length and Breadth, let each of them be divided into 10 equal Parts, with this Proviſo, that nine of the ten Parts ſtand in the Middle of each Rod, and the other tenth Part muſt be divided into two Parts; half whereof muſt be ſet at the one End, and the other Half at the other End of the ſame Rod. Then from Side to Side draw right Lines from Diviſion to Diviſion, ſo is your Rod divided into Squares on every Side thereof. Laſtly, from Corner to Corner of every of theſe Squares draw a Diagonal Line, and that will divide every Square into two Triangles. The Rods being thus prepared, and lined firſt into Squares, and then into Triangles, they are then fit to be numbred.

The

The Figure 1, at the beginning of the Book, ſhews the Form of one of theſe Rods lined as it ought to be.

CHAP. II.

How theſe Rods are to be numbred.

IN the two half Squares, which are at the Ends of each Rod on every Side, there are ſet one ſingle Figure, on each Side of every Rod one, in the Diviſion at the End thereof; ſo every Rod containing four Sides, ten Rods will contain 40 Sides, and ſo conſequently will have 40 ſingle Figures at the Ends of every of them; that is, there will be upon the ten Rods amongſt them four Figures of each kind, that is, four Ones, 1111; four Two's, 2222; four Threes, 3333; four Fours, 4444; four Fives, 5555; four Sixes, 6666; four Sevens, 7777; four Eights, 8888; four Nines, 9999; four Cyphers, 0000.

And here it is to be noted, that what Figure ſoever it be, that ſtandeth at the Top of the Rod alone, the Figure

gure that ſtandeth alone on the other Side of the ſame Rod maketh that Figure up the number 9. As for Example: If 1 ſtands on one Side, 8 will ſtand on the other Side, ſo 2 and 7 *&c.* as in this Table, where

	1		8	
	2		7	
	3	ſtands alone	6	
	4	at the Top of	5	ſtandeth on
If	5	any Side of	4	the other
	6	any of the	3	Side of the
	7	Rods, then	2	ſame Rod.
	8		1	
	9		0	
	0		9	

This alſo is to be obſerved, in the Figuring of every Rod, that what Figure ſoever ſtandeth alone at the Top, or ſuperior Part of the Rod, the Figure, or Figures that ſtand in the two Triangles, next underneath it, is double to the Figure which ſtandeth at the Top. And the Figures which ſtand in the next two Triangles below, that is three Times as much as the Figure above. And that in the

the fourth Place, or Triangles, is four Times as much as the Figure above &c. till you come to the loweſt Triangles in that Rod, and then the Figure, or Figures that ſtand in thoſe Triangles, are nine Times as much as the Figure which ſtandeth at the Top of the Rod.

So if a Rod have 4 at the Top thereof, the two Triangles, which are juſt and next under it, have only 4 in them, which is equal to 4; in the next two Triangles below there is 8, which is double to 4; in the two Triangles below them is 1 and 2, which together make 12, which is three Times as much as the 4 at the Top; the next Triangles have in them 16, which is four Times as much; the next 20, which is five Times as much; the ſixth hath 24, which is ſix Times as much; the next Triangles have in them 28, which is ſeven Times 4; the next hath 32, which is eight Times as much; and the laſt Triangles at the bottom have 36 in them, which is nine Times as much. All which is viſible by Figure II, at the beginning of the Book.

And

And is evident enough by this little Tabe following, which is the Table of Multiplication, commonly called *Pythagoras*'s Table.

The Figures in the	Figure at the Top of each Rod										Square which are Times as much as the Figure at the Top.
	0	1	2	3	4	5	6	7	8	9	
First	0	1	2	3	4	5	6	7	8	9	1
Second	0	2	4	6	8	10	12	14	16	18	2
Third	0	3	6	9	12	15	18	21	24	27	3
Fourth	0	4	8	12	16	20	24	28	32	36	4
Fifth	0	5	10	15	20	25	30	35	40	45	5
Sixth	0	6	12	18	24	30	36	42	48	54	6
Seventh	0	7	14	21	28	35	42	49	56	63	7
Eighth	0	8	16	24	32	40	48	56	64	72	8
Ninth	0	9	18	27	36	45	54	63	72	81	9

Thus have you the *Fabrick*, *Inscription*, and *Numbring* of these Rods, according

cording to the Inventor's Contrivance of them. He makes mention of them, and hath in his Book ſet the Figure of the ſaid Ten, of one of which Ten I have given you a Scheme at the beginning of the Book, which is Figure II. I will now proceed, to give you the Deſcription of theſe Rods in another more commodious Form.

CHAP. III.

A Deſcription of theſe Rods, according to their beſt and lateſt Contrivance.

THE Deſcription, which I ſhall here give of theſe Rods, varies not at all from that before delivered in the Matter of which they are made, for theſe may be made either in Silver, Braſs, Wood, Ivory, *&c.* Neither do they differ in their Dividing, nor yet in their Numbring: Only, whereas my Lord *Nepeir* maketh them ſquare, each Rod to contain four Sides, theſe are made flat, conſiſting

ſiſting each Rod but of two Sides, and contain in Length about 2 Inches $\frac{2}{10}$, and in Breadth $\frac{1}{2}$ of an Inch, and in Thickneſs $\frac{1}{12}$ of an Inch.

One Set of theſe Rods conſiſteth of five Pieces, and therefore hath but ten Faces or Sides; whereas thoſe of the Lord *Nepeir*'s conſiſted of 40 Plains, or Sides.

Upon one of theſe five Pieces (a Figure whereof is at the Beginning of the Book, noted with Figure 3) you have a Cypher at the Head of the firſt Piece, and 9 at the Bottom thereof. Upon the ſecond of them, you have 1 at the Head, and 8 at the Bottom; upon the Third, you have 2 at the Head, and 7 at the Bottom; upon the Fourth, 3 at Top, and 6 at Bottom; and upon the Fifth, you have 4 at the Top, and 5 at the Bottom. Every of the two Figures, at the Top and Bottom together, make 9; as 0, and 9 is 9, 1 and 8, 2 and 7, 3 and 6, 4 and 5. And here obſerve, that the Figures, 9 8 7 6 5, which ſtand at the Bottom of the Scheme, ſtand with their Heels upwards, in this manner, 6 8 L 9 S, ſo do all the other Figures

under them, till you come to the double Line, which is in the Middle of the Scheme, noted with *A* and *B*, at which Line, if the Scheme were cut into two Pieces, and folded or paſted on the Backſide of the other Half, ſo that the 9 at the Bottom were placed upon the Cypher at the Top, and ſo 8 upon 1, 7 upon 2, 6 upon 3, and 5 upon 4; and then the Scheme cut again into five little Slippets, by the down-right Lines, theſe five Slippets would exactly repreſent one ſet of theſe Rods; for upon one of theſe Pieces, you ſhould have a Cypher upon one Side, and 9 on the other; upon the next 1 and 8, upon another 2 and 7, on another 3 and 6, and on the other 5 and 4; both the Figures on either Side making 9, as before was deſcribed.

Theſe five Slippets do now contain the whole Table of *Pythagoras* before mentioned, but ſo few are not of ſufficient Uſe, neither are the Ten before mentioned of the Lord *Nepier*'s Order; for their can be but four Figures of one kind, which in all Caſes is not ſufficient.

There-

Therefore as theſe Rods are made now-a-days, they do commonly make ſix Sets of them, that is, 30 Pieces, which contain 60 Faces, and theſe will be of good Uſe, and there will ſeldom be found a Want, which, in thoſe of the Inventor's, there will often be; except you have a great Quantity, which will be far more cumberſome, than theſe here deſcribed; for there is required as much Metal, or Wood, in one of his, as in four of theſe; and then, for his four Sides, we have here eight.

Concerning a Caſe for theſe Rods.

For the orderly keeping, and ready finding of theſe Rods, I have often (for myſelf and others) had a Box made of Walnut-Tree, or Pear-Tree, with five Partitions in it, each Partition to hold five or ſix Sets of theſe Rods, or more, if more Rods were required. Every of theſe Partitions being figured on the Side thereof next the Eye, with ſuch Figures as the Rods in ſuch a Partition had Figures at the Top, ſo that the Party, that was to uſe them, could take them as readily out of his Parti-

tion, as a Printer can take his Letters out of his reſpective Boxes to make any Word.

In this Box there is alſo convenient Room made for one other Rod, double in Breadth to theſe here deſcribed; but of the ſame Length and Thickneſs; upon the one Side whereof there is a Table or Plate uſeful in the Extracting of the Square-Root, and on the other Side, another for the Extracting of the Cube-Root, the Figure whereof is at the beginning of the Book, noted with Square, Cube.

But I ſhall forbear to ſay any thing of them, till I come to ſhew you how to extract the Square and Cube Roots, by the Help of them and the Rods.

Of a Board with a Frame, upon which to lay your Rods, when any Operation is to be wrought by them, known by the Name of a TABULAT.

In the uſing of theſe Rods care is to be had, firſt, of the orderly laying of them; and then, ſecondly, for the keeping of them in that Poſition till your Work be ended. For the effecting whereof, both neatly and certainly, there

there is a little Table or Frame contrived, containing in Breadth $\frac{1}{20}$, of an Inch more than the Length of the Rods, and in Length at Pleaſure, but it may well be about once and a half the Length of the Breadth.

It ought to be made of a thin Piece of Pear, or Walnut-Tree, or of ſuch Matter as your Box or Caſe is made of; and it may very commodiouſly be contrived to be put into the Box, as I ever had them made to do, for that I found it inconvenient to carry looſe.

Upon the Superficies of this Board, cloſe to one of the Edges thereof, muſt be glewed, or otherwiſe faſtned with Pins, a ſmall Piece of the ſame Matter, and alſo of the ſame Length, Breadth, and Thickneſs of one of your Rods, which muſt be divided into 9 equal Parts, and Lines drawn croſs the Piece; ſo will there be 9 Squares, in which you muſt grave or ſtamp the nine Digits, beginning with 1 at the Top, and ſo deſcending by 2 3 4 to 9 at the Bottom thereof: And it were neceſſary, that theſe Figures (as alſo thoſe which are at the Head of every of your Rods) were graven or ſtamped of

ſomething a bigger Figure, than the other Figures of your Rods are.

Under the End of this Ledge, beginning at the Figures, and ſo continuing the whole Length of the Board, muſt another Ledge, of the ſame Matter and Thickneſs as the other, be glewed or pined, and then is your *Tabulat* finiſhed. A Figure whereof you have at the beginning of the Book, noted with Figure 4. It is called a *Tabulat*, for that, when the Rods are laid thereon, for any Operation to be wrought by them, we uſually ſay, the Rods are tabulated.

Being thus prepared with Rods and Tabulat, you are ready for the Work intended by them, and for which chiefly they were invented.

Thus much for the Fabrick, Inſcription, and Numbring of theſe Rods; let us now come to ſhew the Uſes of them.

CHAP. IV.

To what Uſe theſe Rods generally ſerve.

THE chief Uſes, to which theſe ſmall Rods ſerve, I in part intimated at the Beginning, to which Effect I ſhall repeat it again——For by them all Manner of Multiplications and Diviſions, as alſo of the Extraction of both the Roots, either Square or Cube, are ſo facilly and expeditiouſly performed, and that by the Help of Addition and Subſtraction only, that it is (as I may well ſay) inconceiveable; for here is no Charge at all required of the Memory, and you ſhall aſſuredly take your Quotient-Figure in Diviſion always certain, neither too great, nor too little, an Inconvenience ſo prejudicial, that I leave it to the Cenſure of ſuch as have found it, to their great Loſs of Time, and other Vexation which it hath put them to. But, ceaſing to ſay more of their Properties, I will now come to ſhew their Uſe.

CHAP. V.

How to apply, or lay down, any Numbers by the Rods.

PROP. I.

Any Number being given, how to tabulate, or lay down the ſame by the Rods.

LET it be required to tabulate, or lay down this Number, 3496.

Firſt, From among your Sets of Rods (or out of your Caſe) take four of them, of which let one of them have the Figure 3 at the Top thereof, and lay it upon your Tabulat, cloſe to the Edge thereof. Then,

Secondly, Take another Rod from your Caſe, which hath the Figure 4 at the Top of it, and lay that alſo upon your Tabulat, cloſe by the Side of the other.

Thirdly, Take another Rod, which hath the Figure 9 at the Top of it, and lay

lay that upon your Tabulat, cloſe by the other two.

And, laſtly, take a fourth Rod, having the Figure 6 at the Head thereof, and lay that alſo upon your Tabulat, cloſe by the reſt.

Theſe four Rods thus taken, and laid upon the Tabulat, you ſhall ſee in the uppermoſt Row (which ſtandeth againſt the Figure 1, on the Side of your Tabulat) theſe four Figures, 3 4 9 6, that is 3496, equal to your given Number. In the ſecond Row (againſt the Figure 2 of your Tabulat) you ſhall find the Double thereof. In the Third (againſt the Figure 3) you ſhall find the Triple thereof. In the Fourth, the Quadruple thereof. In the Fifth, the Quintuple; and ſo on to the Ninth and Laſt, in which you ſhall find the Noncuple of the Number given

PROP.

PROP: II:

How these Rods will appear when tabulated, and, being tabulated, how to read the Multiplication of that Number so tabulated, by any of the nine Digits.

THE four Rods being tabulated, according to the Precepts delivered in the preceding Propoſition, they will appear exactly as they are repreſented in Figure 4 at the Beginning of the Book, which Figure lively repreſents the four Rods lying upon the Tabulat, which mind well; for upon the true Tabulating, and right Reading of the Rods ſo tabulated, depend the whole Work.

The Rods thus tabulated, and as you ſee them in Figure 4, do to the Eye appear in the Form of a Glaſs-Window, every Pane thereof repreſenting a Rhomboiades, or Diamond-Form: In the Reading of the Figures which are in theſe ſeveral Rhomboides's, or Diamond-Forms, obſerve theſe few Directions

tions following, which will fully illustrate the whole Bufinefs intended, and therefore efpecially to be minded.

Note I. *That the Figures upon the Rods are to be read beginning at the right Hand, and reading towards the left*; which is contrary to our common Courfeo f Reading and Writing, which is from the left Hand towards the right.

II. *That in every Rhomboides or Diamond, there are either one Figure, or two Figures, but never more than two.*

III. *If there be but one Figure in a Rhombus, then that Figure is the Figure to be fet down alone*, (be it either a Figure, or a Cypher) *but if there be two Figures in a Rhomboides* (as for the moft part there is) *then add them two Figures together, and fet down their Sum in one Figure.*

IV. *But if the Sum of the two Figures, in one Rhomboides or Diamond, do exceed ten, then you muft fet down the overplus above ten, and keep one in Mind,*

Mind, which one you muſt carry to the next Rhomboides.

V. *That the firſt towards your right Hand, and the laſt towards your left Hand, are but half Rhomboides*'s *or Diamonds, and never have in them more than one Figure; but all between them are whole ones, and for the moſt part have two Figures in them.*

VI. *If in either Rhomboides, or half Rhomboides, you find no Figures, but Cyphers, you muſt not neglect, but ſet them down as if they were Figures.*

These Rules being rightly underſtood, all that follows will be familiar and eaſy, and theſe I ſhall explain by Example following.

Example.

For the Illuſtration of the preceding Rules, we will make uſe of thoſe Rods which were before tabulated, therefore have recourſe to Figure 4 at the beginning of the Book, where this Number 3496 is tabulated.

The Figures at the Top of the four Rods are theſe, 3 4 9 6, which ſignify the

the former given Number 3496, and this Number ſtands againſt the Figure 1 on the Side of the Tabulat. Then, I ſay, that the Figures in the next Row, ſtanding againſt the Figure 2 of the Tabulat, are double thereunto, which I prove thus:

Repair to the Rods as they lie upon the Tabulat, and in that Row which lieth againſt the Figure 2, you ſhall find in the firſt half Rhomboides, towards your right Hand (where by Rule 1 you muſt begin) the Figure 2; wherefore ſet down with your Pen upon Paper the Figure 2; in the next Rhomboides, in the ſame Row, you will find 8 and 1, which added make 9, ſet down 9 on the left Hand of 2; in the next Rhombus you ſhall find 8 and 1 again, which is 9 alſo; ſet down 9 on the left Hand of the other; and in the laſt Rhomboides you ſhall find only 6, wherefore ſet down 6 on the left Hand of 9: So have you in all 6992, which is double to 3496.

Again, the Figures in the Row, which ſtand againſt the Figure 3 in the Tabulat, are triple to 3496; for in the firſt half Rhomboides, towards your

right Hand, you have 8, ſet down 8; in the next Rhombus you have 7 and 1, which is 8, ſet down 8 again; in the next you have 2 and 2, which is 4, ſet down 4; in the next Rhombus you have 9 and 1, which makes 10, ſet down 0 and carry 1; but it is the laſt Rhombus, and becauſe there is never another to carry the 1 unto, you muſt therefore ſet it down: So have you this Number 10488, which is triple to 3496.

Again, the Figures ſtanding againſt 4 in the Tabulat are Quadruple to 3496; for in the half Rhombus you have 4, ſet it down; in the next 6 and 2, which is 8, ſet that down; in the next 6 and 3, which is 9, ſet that down; in the next 2 and 1, which is three, ſet that down; and in the laſt half Rhomb. you have 1, which alſo ſet down: So have you 13984, which is quadruple to 3496.

Alſo, of the Figures againſt 5 in the Tabulat, the firſt is a Cypher, therefore put down 0; the next is 5 and 3, which is 8, ſet down 8; the next is 0 and 4, ſet down 4; the next is 5 and 2, that is 7, ſet down 7; and the laſt is 1, there-

therefore ſet it down : So have you in all 17480, which is Quintuple to 3496.

Againſt 6 in the Tabulat, you have in the firſt place 6, ſet it down ; then in the next 4 and 3, that is 7, ſet that down ; in the next 4 and 5, that is 9, ſet 9 down ; in the next you have 8 and 2, that is 10, ſet down 0 and carry 1 to the next Rhomb. where you find only 1, to which add the 1, which you carried from the Rhomb. before, and it makes 2, ſet down 2: So have you 20976, which is ſix times 3496.

Againſt 7 in the Tabulat you have firſt 2, ſet it down ; then 3 and 4, which is 7, ſet 7 down ; in the next, 8 and 6, which is 14, which being above 10, ſet down 4, and carry 1 to the next Rhomb. where you have 2 and 1, which is 3, and 1 which you carried makes 4, ſet down 4 ; then in the laſt Place you have only 2, which ſet down : So have you in all 24472, which is ſeptuple to 3496, or ſeven times as much.

Againſt 8 in the Tabulat you have firſt 8, which ſet down ; then 2 and 4, which is 6, ſet 6 down ; then 2 and 7, which is 9, ſet 9 down ; then 4 and 3, which is 7, ſet 7 down ; and laſtly 2,

ſet that down: So have you 27968, which is octuple to 3496, or eight times as much.

Laſtly, againſt 9 in the Tabulat, you have in the firſt Place 4, ſet that down; in the next you have 1 and 5, which is 6, ſet 6 down; in the next place you have 6 and 8, which is 14, ſet down 4, and carry 1 to the next Rhomb. where you find 7 and 3, that is 10, which with 1 that you carried makes 11, ſet down 1, and carry 1 to the next Rhomb. where you find only 2, and the 1 carried makes 3, therefore ſet down 3: And ſo you have 31464, which is noncuple to 3496, or nine times as much as the tabulated Number.

Thus have I given you Examples, in ſhewing you how the Numbers upon the Rods are to be read and written down; and in the Delivery of this Example, I have made the whole Work, which is to follow, ſo plain and eaſy, that the meaneſt Capacity (I think) if he can but tell his Figures, and add any two Figures together, he may, by this here delivered, read or write down any Number that can be tabulated: And, that

that you may thoroughly underſtand this Chapter before you proceed further, I will give you the Products of 7009078, multiplied by all the nine Digits, which I would have yourſelf to tabulate, and ſee if you find your Working by your Rods to agree with thoſe which are here written, which Numbers if they do, you need not ſcruple at the moſt difficult that can be propoſed to you; therefore ſtudy it, and try it.

7009078

7009078 being multiplied by	2	Produceth	14018156
	3		21027234
	4		28036312
	5		35045390
	6		42054468
	7		49063546
	8		56072624
	9		63081702

Thus have I ſufficiently deſcribed theſe Rods, and the Manner of Numbring upon them; and now I think it Time to apply them to that Uſe for which they were intended; namely, the more difficult Parts of Arithmetick, as

Multiplication, Divifion, and Extraction of Roots; but firft let me give you

An Admonition concerning Addition and Subftraction.

Whereas it was the difficult Operations of *Arithmetick*, which, by the Benefit of thefe Rods, the Inventor chiefly aimed at (of which Kind he efteemed *Multiplication*, *Divifion*, and *Extraction of the Square* and *Cube Roots*) he omitted to fay any Thing concerning *Addition* and *Subftraction*, as Things obvious to every *Tyro*: He therefore omitting them, begins to fhew the Ufe of his Rods in *Multiplication*, whofe Method I fhall here follow.

CHAP. VI.

Multiplication by the Rods.

IN multiplying by the Rods, you are to confider (as in Vulgar Arithmetick) three Terms, Things, or Numbers, *viz.*

1. The *Multiplicand*, which is the Number to be multiplied.

2. The

2. The *Multiplier*, which is the Number by which the *Multiplicand* is multiplied.

3. The *Product*, which is the Sum produced by the Multiplying of the two former together.

And here note, That the *Product* doth contain the *Multiplicand*, ſo many Times as there be *Unites* in the *Multiplier*.

Thus for the Definition of *Multiplication*: Now for the Working thereof by the Rods; for which this is

THE RULE.

Firſt, *Set down upon your Paper the Multiplicand, and orderly under it the Multiplier.* [It matters not greatly which of the two given Numbers be made *Multiplicand* or *Multiplier*; but it is uſual and beſt to make the greateſt Number *Multiplicand*, and the leſſer *Multiplier*.] *Then draw a Line with your Pen under them, and having tabulated your Multiplicand (or greater Number) look what Numbers in your Rods ſtand againſt the firſt Figure towards your right Hand, and that Number which you ſhall find upon your Rods ſtanding againſt that firſt Figure found in your Tabulat,*

ſet

set down under your Line, which you formerly drew under your Multiplicand and Multiplier; and having so done with the first Figure of your Multiplier, do so with the rest, setting them down one under another, removing every Figure one Place more towards the left Hand, than that which went before it, as is done in common Multiplication, and as you see in the following Example.

Example 1. Let it be required to multiply 3496, by 489. As if it were required to know how much 489 Times 3496 would amount unto.

First, Set down your given Numbers 3496, and 489, one under another, and draw your Line under them, as here you see done.

Secondly, 3496, your Multiplicand, being tabulated, and 9 being the first Figure to the right Hand in your Multiplier, look upon your Rods, what Sum there

```
   3496 Multiplicand
    389 Multiplier
  -----
  31464
 27968
13984
-------
1709544 Product.
        Sec.
```

there ſtands againſt 9 in the Side of your Tabulat, and you ſhall find (as by the Rules in the ſecond Prop. of the fifth Chap. you was directed) 31464, which is the Product of 3496, multiplied by 9; wherefore ſet down this Number 31464 under your Line, as you ſee in the Example.

Thirdly, Look what Sum upon the Rods ſtands againſt 8, which is the ſecond Figure of your Multiplier, and you ſhall find 27968; ſet this Number under the former, moving it one Place forward towards the left Hand.

Fourthly, Look what Sum upon the Rods ſtands againſt 4, which is the third Figure in your Multiplier, and you ſhall find 13984, which ſet down under the other, one Place more to the left Hand.

Laſtly, Under theſe three Sums draw a Line, and add the three Sums together, and they make 1709544, which is the Product of 3496, multiplied by 489; and this 1709544, the Product, contains 3496, the Multiplicand, 489 Times.

Practiſe well this firſt Example, and compare it with the Rods as they are tabulated in Figue 4, at the beginning of

of the Book, as alſo with the Rules in the fifth Chapter, and you may perform any Multiplication. However, I will give you one or two more Examples, and ſome other Ways of *Multiplication.*

Example 2. Let it be required to multiply the ſame Sum 3496 by 261.

3496 261 ——— 3496 20976 6992 ——— 912456	Set the Numbers down as here is done, then look upon the Rods for the Product of 3496 by 1, and you ſhall find it to be the ſame, wherefore ſet down 3496 under the Line. —— Then look upon

the Rods for the Product of 3496 by 6, and you ſhall find it to be 20976, which ſet down under the other Number, one Place more towards the left Hand.—— Again, look in the Rods for the Product of 3496 multiplied by 2, and you ſhall find it to be 6992, which ſet down under the other two.

Laſtly, Draw a Line under them, and add the three Numbers together in order as they ſtand, and the Sum of them will be 912456, which is the Product of 3496, multiplied by 261.

Exam-

Example 3. Let it be required to multiply the ſame Number 3496 by 520.

Set down your Numbers as here you ſee done: —— Then, becauſe the firſt Fi-

3496
520
6992
17480
1817920

gure of your Multiplier, towards your right Hand, is a Cypher, wholly omit it, and multiply 3496 by 52 only, ſo ſhall you find the Product of 3496 by 2, to be 6992, which ſet down: Alſo the Product by 5 will be 17480, which ſet down under the other one Place further; then draw a Line ——, and add theſe two Sums together, and they make 181792, to the which, if you add a Cypher for the Cypher which you omitted in your Multiplier, the Sum will be 1817920, which is the Product of 3496 by 520.

Example 4. Let it be required to multiply the ſame 3496 by 7003.

Set down your Numbers as before, and as you ſee here done; then, having

3496
7003
10488
24472
24482488

tabulated 3496, ſee what the Product thereof is upon the Rods, being multiplied by 3, the firſt Figure in your Multiplier, and you ſhall find it to be 10488, which ſet down under

under the Line: —— Then the two next Places of your Multiplier being Cyphers, make two Pricks under the former Number, one under 8, the other under 4, as you ſee in the Example, or inſtead of 2 Pricks, you may make two Cyphers: — Then look on the Rods for the Product of 3496 by 7, and you ſhall find it to be 24472, which ſet down under the other Sum, beginning your Number at the fourth Place, or beyond the two Pricks or Cyphers. Laſtly, Draw a Line, and add theſe two Sums together, and their Sum is 24482488, which is the Product of 3496 multiplied by 7003.

Thus have you four Examples in *Multiplication*, in which are included all the Varieties that may at any Time happen in that Rule, *viz.* Two, where the Multiplier conſiſted all of Figures, as in the firſt and ſecond Example they did. —— Another, where the latter Place of a Multiplier conſiſted of a Cypher. —— And this laſt Example, where Cyphers were intermixed among the Figures.

And thus much for this Kind of Multiplication; but, before I leave, I will ſhew you Ano-

Another Form of Multiplication.

Whereas, in the foregoing Form of Multiplication, which is the beſt and moſt uſual, (only I inſert this following for Variety) you began (your Rods being tabulated) with that Figure of your Multiplier, which ſtands next your right Hand; but there is no neceſſity for that, for you may begin with that Figure which ſtandeth next to your left Hand, and by ſo doing, and placing your ſeveral Products one Place more to the right Hand, as you did before place them to the left Hand, thoſe Products added together in the Form they then ſtand, ſhall produce a Product equal to the former.

Example. For our Example we will take the firſt Example foregoing, at the beginning of this Chapter, where it was required to multiply 3496 by 489. Set the Numbers down as before in that firſt Example, and as you ſee here done————————————

$$\begin{array}{r} 3496 \\ \underline{489} \\ 13984 \\ 27968 \\ \underline{31464} \\ 1709544 \end{array}$$

Then 3496 being tabulated, look upon your Rods for the Product thereof, multiplied by 4, (which is the firſt Figure of your Multiplier towards your left Hand) and you ſhall find the Product thereof to be 13984, which ſet down. — Secondly, look the Product of 3496 by 8 (your ſecond Figure) and you ſhall find it to be 27968, which muſt not be ſet down as in the other firſt Example, but as you ſee it in this; 8, the firſt Figure thereof, muſt be ſet one Place forward towards the right Hand, as in the other, it was ſet a Place backward towards the left. — Laſtly, ſeek in your Rods for the Product of 3496 by 9, your laſt Figure, and you ſhall find it to be 31464, which ſet under the other two Numbers, yet one Place more to the right Hand. — So a Line being drawn under, and theſe three Numbers added together, produce 1709544, equal to that in the firſt Example: And that you may the better ſee the Difference of the Work, I have ſet them one by the other.

As

As in the first Example,	As in this Example,
3496	3496
489	489
31464	13984
27968	27968
13984	31464
1709544	1709544

One Example more in Multiplication (which ſhall be for Advertiſement and Direction) I will give, and ſo conclude Multiplication.

I ſaid, in the general Rule for working of Multiplication (at the beginning of this Chapter) that it mattered not which of your Numbers were made the Multiplicand, or which the Multiplier, of which I will here give you a Preſident, where the leſſer Number ſhall be tabulated, and the greater Number only ſet down; and I will work it here according to this laſt Way of Multiplication, and the Example ſhall be as followeth.

Example. Let it be required to multiply 868437 by 3496, and let 3496 (the leſſer Number) be tabulated.

Let the Numbers be ſet as you here ſee, then 3496 being tabulated, begin with the firſt Figure towards the left Hand of your Multiplier, which here is 8, and upon your Rods find the Product of 3496 multiplied by 8, which is 27968, ſet that down under the Line.——Then find the Product of 3496 by 6, the ſecond Figure of your Multiplier, and you ſhall find that to be 20976, ſet this Number under the former, one Place more towards the right Hand. —— Again, the third Figure of your Multiplier is 8, whoſe Product is 27968, as before, ſet that under the other, ſtill one Place more to the right Hand. —— In this Manner do with the other Figures of the Multiplier; as 4, the next Figure, whoſe Product is 13984, which alſo ſet down a Place forward. — So alſo the Product of 3, which is 10488, which ſet down. —— And laſtly, of 7, which is 24472. —— All theſe Products being ſet down in the Order as you ſee them in the Margent, if you add

```
      3496
    868437
    ------
    27968
     20976
      27968
       13984
        10488
         24472
    ----------
    3036055752
```

add them together, the Sum of them will be 3036055752, which is the Product of 3496, multiplied by 868437, the leſſer Number being tabulated.

Other Ways of Multiplication I could have added, but theſe I eſteem ſufficient.

CHAP. VII.

Diviſion by the Rods.

AS in Multiplication, ſo in Diviſion, there are three Numbers, Terms, or Things required, *viz.*

1. The Dividend, or Number to be divided.

2. The Diviſor, or Number by which the Dividend is divided; and,

3. The Quotient, which is the Number iſſuing from the Dividend's being divided by the Diviſor; and this Quotient doth always conſiſt of ſo many Unites, as the Diviſor is Times contained in the Dividend.

Thus much for the Definition of Diviſion, now let us come to the Practice

of it by the Rods, to perform which, his is

THE RULE.

Tabulate the Diviſor, (which is always the leſſer Number of the two given) and ſet down the Dividend, and ſet the Diviſor on the left Hand, and draw a crooked Line on the right Hand for your Quotient, as in common Arithmetick; then look upon your tabulated Rods (always) for the Number, leſs than the Number in the firſt Figures of your Dividend, and what Figure ſtands againſt that Number, on the Edge of your Tabulat, muſt be the Figure you muſt put in your Quotient; and that Number you muſt always ſubſtract from the Figures of your Dividend, and to the Remainder add another Figure, ſo proceeding from Figure to Figure, till your Diviſion be wholly ended.

Example. Let it be required to divide 709544, by 3496. Having tabulated 3496, ſet down your Dividend, your Diviſor on the left Hand thereof, and a crooked Line for the Quotient on the right Hand thereof, as by the Rule preceeding you were directed, and as you

you fee done in the Example adjoining.

And becaufe, at your firft fetting down of your Divifor 3496, it would reach (if it were fet under your Dividend 1709544) as far as the Figure 5, therefore under the Figure 5 make a Prick, to intimate how far you are gone on in your Work, and under this Prick, draw a Line quite under your Dividend, then is your Sum fet down ready for Work, and will appear as you fee here,

3496)1709544(

Your Sum thus prepared, ask how often can have you 3496 in 17095? look in your tabulated Rods for 17095, which you cannot there find, but the neareft Number thereunto among the Rods, which is lefs than 17095 (for you muft always take a lefs Number) is 13984, which Number ftands againft the Figure 4 in the Tabulat, wherefore fet 4 in your Quotient, and 13984 under the Line, and fubftract 13984 from 17095, and there will remain 3111; fo

ſo is the firſt Part of your Diviſion ended, and your Work will ſtand thus,

3111
3496) 1709544 (4
.
―――
13984

Then make another Prick under 4, the next Figure of your Dividend, ſo will the remaining Number be 31114: —— Then look among the Rods for the Number 31114 (or the neareſt leſs than it) and the neareſt leſs you ſhall find to be 27968, which ſtands againſt 8 in your Tabulat, put 8 in your Quotient, and ſet 27968 under 31114, and ſubſtract 27968 from 31114, ſo will there remain 3146, which ſet over Head; ſo is the ſecond Part of your Diviſion ended, and your Work will appear thus,

3146
3111
3496) 1709544 (48
..
――― ―――
13984
27968

Laſtly,

Laſtly, Make another Prick under the next Figure of your Dividend, which is 4 alſo, making the remaining Number to be 31464, ſeek among your tabulated Rods for this Number (or the neareſt leſs) but looking, you ſhall find the very Number, againſt which ſtands on your Tabulat the Figure 9, ſet 9 in the Quotient, and the Number 31464 under the Line, and ſubſtract it from 31464 the Remainder, which ſtands above the Line, and nothing remains; and being there is never another Figure in your Dividend, your Diviſion is ended, and your Work will ſtand thus; and 3496 is contained in 1709544 489 times.

```
              00000
              3146
  Diviſor    3111      Quotient
     3496) 1709544 (489
                •••
           ________
           13984
            27968
              31464.
```

Ano-

Another Example, and by another Way of Division.

Let it be required to divide 912456 by 3496, ſet down your Dividend and Diviſor, draw a crooked Line for your Quotient, and alſo make a Prick under the fourth Figure of your Dividend, and draw a Line under your Dividend; ſo is your Sum prepared to be divided, and will ſtand thus,

3496) 912456 (

Then your Diviſor 3496 being tabulated, look amongſt your Rods for the neareſt Number to 9124, which is leſs, and you ſhall find it to be 6992, againſt which ſtands on your Tabulat the Figure 2; ſet 2 in the Quotient, and this Number under the Line, and ſubſtract it from 9124, and there will remain 2132, to which Number add the next Figure of your Dividend, namely 5, and it makes 21325; under which Number draw a Line, then will your Sum ſtand thus,

3496

3496) 912456 (2

6992
21325

Then among your Rods seek the nearest Number to 21325, and you shall find 20976 to be the nearest Number less, against which in your Tabulat stands 6; set 6 in the Quotient, and 20976 under the Line, substracting it from 21325, which, when you have done, there will remain 349; to 349 add the next Figure in your Dividend, which is 6, your last Figure, and it makes 3496, under which draw a Line, and your Work will stand as you see here,

3496) 912456 (26

6992
21325

20976
3496.

This

This done, look amongſt your Rods for the neareſt Number to 3496, and you ſhall find the exact Number at the Top of the Rods, againſt which ſtand, the Figure 1 on the Tabulat; ſet 1 in the Quotient, and ſubſtract 3496 from 3496, the Remainder is nothing; and ſo is your Diviſion ended, the Work ſtanding thus, and 3496 the Diviſor, is contained in 912456 the Dividend, 161 times.

```
3496) 912456 (361
        • • •
      ______
      6992
      21325
      ______
      20976
        3496
        ______
        3496
        0000.
```

A third Example ready wrought by the laſt and beſt Way of Diviſion.

I will only ſet it down ready wrought, leaving the Practice of it to yourſelf.

Let

Let it be required to divide 73020506 by 3496.

$$
\begin{array}{l}
3496)\,73020506\,(20886\tfrac{3050}{3496} \\
\quad 6992 \\
\hline
\quad\ 31005 \\
\quad\ 27968 \\
\hline
\quad\quad 30370 \\
\quad\quad 27968 \\
\hline
\quad\quad\ 24026 \\
\quad\quad\ 20976 \\
\hline
\text{Rem. } 3050
\end{array}
$$

This Sum thus divided produceth in the Quotient 20886, and 3050 remaining; ſo that the Quotient with Fraction and all is

20886 $\frac{3050}{3496}$, which ſhews

that 3496, the Diviſor, is contained in 73020506, the Dividend, 20886 times, and 3050 remaining.

This Example well practiſed, together with them foregoing, are ſufficient Inſtructions for any Student whatever; and he that can perform theſe, need not deſpair the moſt difficult that can be propoſed. And ſo I conclude with Diviſion.

CHAP. VIII.

Concerning the Rule of Three, or Golden Rule, both Direct and Reverſe, or Reciprocal.

TO diſcourſe of this Rule at large, were to run into a Labyrinth; for it was the Performance of Working Multiplication and Diviſion by the Rods that was here aimed at, and he that can multiply and divide, may command this *Golden Rule*: Wherefore I will ſhew you the Nature or Order of Placing the Numbers, and alſo the Manner of Working an Example in either of them.

The *Rule of Three* is that Rule which teacheth, by having three Numbers, in Proportion one to another given, to find

find a fourth, which ſhall be in Proportion to them alſo.

In this *Rule direct*, the fourth Number which is ſought, is to have the ſame Proportion to the third, as the ſecond Number hath to the firſt: As if the three Numbers given were 2——4——and 8; ſay, as 2 is to 4, ſo is 8 — to what? Multiply 4 by 8 (that is, the ſecond Number by the third) and the Product will be 32, which divide by 2 (the firſt Number) the Quotient will be 16, which is the fourth Number in Proportion to the third, as the ſecond is to the firſt; for as 4 the ſecond Number, contains 2 the firſt Number twice; ſo 16 the fourth Number, contains 8 the third Number twice alſo.

But in the *Reciprocal Rule of Three*, there the Proportion is not as the firſt to the ſecond, ſo the third to the fourth: But as the firſt is to the third, ſo is the ſecond to the fourth. As if the Numbers were 3, 4, and 6, ſay, as 3 the firſt Number, is to 6 the third Number, ſo is 4 the ſecond Number, to what? Multiply 4 the ſecond Number, by 3 the firſt Number, the Product is 12, which divide by 6 the third Num-

ber, and the Quotient will be 2; for as 6 the third Number, contains 3 the firſt Number twice, ſo 4 the ſecond Number, contains 2 the fourth Number twice alſo: And in this conſiſts the Difference between the *Direct* and *Reciprocal Rule of Three.*

Queſtions in each Rule: And

1. In the Direct Rule.

If four Men eat two Pecks of Corn in one Week, how many Pecks will ſerve an hundred Men the ſame Time?

Men	Pecks	Men
4———	———2———	———100

Multiply 2 the ſecond Number by 100 the third Number, the Product will be 200, which divide by 4 the firſt Number, and the Quotient will be 50, and ſo many Pecks will ſuffice 100 Men the ſame Time.

2. In the Reciprocal.

If twelve Men do any Piece of Work in 8 Days, how many Men muſt be imployed to do the ſame Piece of Work in 2 Days.

Days

Days	Men	Days
8	12	2

Multiply 8 the firſt Number, by 12 the ſecond, their Product is 96, which divide by 2 the third Number, the Quotient will be 48, and ſo many Men will do the ſame Work in 2 Days; for as 8 Days are to 2 Days, ſo are 12 Men to 48 Men, *&c.*

CHAP. IX.

Of the Extraction of Roots.

THE Extraction of *Roots*, which is the difficulteſt Part of Multiplication and Diviſion, is expeditiouſly and certainly performed by the Rods; for the eaſy and expedite Performance of which, there are two Rods on purpoſe, one for the Square, the other for the Cube-Root, of which I will ſpeak; firſt, of their Fabrick; ſecondly, of their Uſe.

Of the Fabrick of the Rods for Extracting of Roots.

Of the ſame Matter, and of the ſame Length and Thickneſs of your other Rods, let there be made another Rod, but three Times the Breadth of the former; the Inſcription on one Side ſerving to extract the Square, and that on the other Side for the Cube-Root, each of which are divided into three Rows or Columns.

That which ſerveth for the Square-Root hath in the Top, or uppermoſt Square between the Diagonal thereof, theſe Figures 0-1, in the ſecond 0-4, in the third 0-9, in the fourth 1-6, in the fifth 2-5, in the ſixth 3-6, in the ſeventh 4-9, in the eighth 6-4, and in the ninth or lowermoſt 8-1, which are the Square Numbers belonging to the nine Digits.

In the ſecond Column of the ſame Rod, in the firſt Square is inſcribed 2, in the ſecond 4, in the third 6, in the fourth 8, in the fifth 10, in the ſixth 12, in the ſeventh 14, in the eighth 16, and in the ninth 18.

In the laſt or third Column, there are the nine Digits orderly deſcended; namely,

namely, 1, 2, 3, 4, 5, 6, 7, 8, 9. This Rod thus made is fitted for the Square-Root.

That which ferveth for the Cube-Root hath in the Top, or uppermoft Square of the firft Column towards the left Hand, between the Diagonal thereof, thefe Figures, 0-01, in the fecond 0-08, in the third 0-27, in the fourth 0-64, in the fifth 1-25, in the fixth 2-16, in the feventh 3-43, in the eighth 5-12, and in the ninth 7-29, which are Cube Numbers orderly defcending. —— The fecond Column of this Rod contains thefe Square Numbers, 1, 4, 9, 16, 25, 36, 49, 64, 81, orderly defcending. —— The third and laft Column of this Rod hath in it the nine Digits, 1, 2, 3, 4, 5, 6, 7, 8, 9, orderly defcending alfo.

This Rod thus prepared and infcribed is fit for Extracting of the Square and Cube-Roots, a Figure of either Side whereof you have at the Beginning of the Book: That which ferveth for the Square-Root, having the Word *Square* written over Head; that for the Cube-Root, hath *Cube* written over Head.

Thus having given you the Fabrick and Infcription of the Rods, I will now fhew you their Ufe; and firft,

Con-

Concerning the Extraction of the Square-Root.

In Extracting of the Square-Root, you muſt, as in common Arithmetick, when you have ſet down your Number, make a Prick under the firſt Figure towards your right Hand, and ſo ſucceſſively under every ſecond Figure; then under thoſe Pricks draw two Lines parallel, whereinto ſet the Figures of your Root as you find them: Your Number being thus placed and pricked as before is directed, and as in the following Example you ſee done, you may proceed to extract the Root thereof as followeth.

Example 1. Let it be required to find the Square-Root of this Number 12418576; firſt, make a Prick under 6, another under 5, another under 1, and another under 2, under which Points draw two Lines, in which you muſt place your Root, and then will your Number ſtand thus,

12418576
 . . . .

Take the Rod for Extracting of the Square-Root, and look in the firſt Row or

or Column thereof, for the neareſt Number you can find there leſs than 12, (which is as far as the firſt Prick in your Number reaches) and you ſhall find 9, againſt which in the third Column you ſhall find three, ſet 3 under the firſt Point between the Lines, and 9 under the Line; and, ſubſtracting 9 from 12, there will remain 3, which ſet over 12, ſo will your Number ſtand thus:

```
    3
 12418576
   .  .  .  .
---------------
    3
---------------
    9
```

Then in the middle Column of your Rod, between 9 and 3, there ſtands 6; take therefore one of your Rods which hath 6 at the Top thereof, and lay it upon your Tabulat by the left Side of your Square Rod, then being there is 341 to the next Prick, ſeek the neareſt Number leſs upon your two Rods, and you ſhall find the next leſs to be 325, againſt which, in the laſt Column of your Square-Rod, ſtands 5, therefore place 5 under your ſecond Prick, and ſet 325 under 341, and ſubſtracting it from 341, there will remain 16, which ſet over Head, then will the Sum appear thus:

16	
3	
12418576	
. . . .	
3 5	
9	
325	

And in the middle Column of your Square-Rod against this 5, there ſtands 10; for this 10 you ſhould take a Rod that hath 10 at the Top, but being there is no ſuch, take therefore one that hath a Cypher, and place that between your Square-Rod and your Rod of 6, and change your Rod of 6 for one of 7, then ſhall you have upon your Tabulat one Rod of 7, another of 0, and your Square Rod.

Thus muſt you always do, when the Number in the middle Column exceeds 10.

Then, looking upon your Sum, you ſhall find 1685 to your third Prick, look therefore upon your Rods for the neareſt leſs Number, which you ſhall find to be 1404, againſt which ſtands 2 in the laſt Column, ſet 2 between the Lines under the third Prick, and 1404 under 1685, and, ſubſtracting it from 1685, there will remain 281, which place above, ſo will your Sum ſtand thus:

281

```
   281
  16
 3
12418576
 .  . . .
---------
 3 5 2
---------
 9
 325
  1404
```

And becauſe the Number, ſtanding againſt in the middle Column of your Square Rod between 1404, and 2 was 4, ſet 4 under your laſt Prick, and take a Rod of 4, and put it between your Square Rod, and your Rod of 0; and becauſe 28176 remains upon your Sum to the laſt Prick, look upon your Rods for the neareſt Number thereunto, and you ſhall find the very Number it ſelf to ſtand againſt the Figure 4, ſet therefore 28176 below, and ſubſtract it from that above, and there will remain nothing, which denotes the Number 12418576, to be a ſquare Number, and the Root thereof to be 3524, and the Work finiſh'd will ſtand thus:

```
          00000
          281
         16
        3
Square 12418576
       ..  .  .  .
      ----------
        3  5 2  4  Root,
      ----------
        9
        325
         1400
          28176
```

This Sum, had it been wrought by the ſecond Way of Diviſion, which I ſhewed in Chapter 7, it would have ſtood as followeth:

```
Square 12418576 (3524 Root.
        .  .  .  .

       9
       -----
       341
       325
       -----
        1685
        1404
       ------
         28176
         28176
         -----
         00000
```

Caution.

Caution.

If at any Time you look for the Remainder upon your Rods, and you cannot find it there, you muſt then place a Cypher between the Lines, and proceed to the next Figure, as by trying this other Example, which I have inſerted for Practice, will appear.

Another Example added for Practice.

90

54895

67

21

2

. . . . . .

117716237694

343098

9

256

2049

617481

5489504.

CHAP. X.

Concerning the Extraction of the Cube-Root.

THERE is ſomewhat more Difficulty in Extracting of the Cube, than of the Square Root. Wherefore (before I come to an Example) I will deliver the Manner of the Operation, together with ſuch Cautions as are to be obſerved in the Performance thereof; all which immediately follow in this

GENERAL RULE.

Write down the Number whoſe Cube Root you are to extract, and under the firſt Figure towards the right Hand make a Prick or Point, and ſo under every third Figure towards the left Hand, till you come to the end of your Number. Under theſe Pricks draw two parallel Lines, (as you did in Extracting the Square Root) between which Lines you are to place the Figures of your Root as you find

find them: —— *Then beginning at the Figure (or Figures) of the left Hand Prick, and going forward towards the right Hand, extract (by Help of the Rod for Extracting the Cube Root) their Root, or, if the true Number be not on the Plate, then the nearest less, and, placing this Root (which never exceeds one Figure) between the Lines, and under its Point, take its Cube from the uppermost Figure, which stands before (or leftwards of) the first Point, and note the Remainder above.*

Secondly, *Keep the Triple of this Root found, in the Head or Top of the Rods, and triple the Square of the same Root, and set this Triple on the Head of the Rods, and apply it leftwards of the Cubick Rod, and the reserved Rod (or Rods) rightwards, the Cubick Rod being in the midst between them; and out of the left Hand Rods, and the Cubick Rod together, pick or find out the Multiple, (or next less Number than the Figures preceding the second Point) which write apart in a Paper, and note its Quotum over its utmost right Hand Figure, and write the Square of that Quotum leftwards from the Quotum itself, even in that Order as you find them in your Cubick Rod; and*

under every ſeveral Figure of this Square, write their Multiples found rightwards, even ſuch as the Figures themſelves do ſhew; ſo that every Multiple may end under its Figure or Quotum: Then add together theſe Multiples croſs-wiſe, and take their Sum from the Figures foregoing the ſecond Point, and write the Remainder over them; but write the right Hand Quotum, before noted, under the ſecond Point between the Lines, for the ſecond Figure or Quotum of the Root: And ſo is performed the Operation of the ſecond Point, which you muſt repeat through the ſeveral Points, even to the laſt.

But in the Practice by this Rule, you may ſometimes be at a ſtand, wherefore to this *GENERAL RULE* (that there may be no Obſtacle) I will add theſe two *CAUTIONS.*

CAUTION I.

But in all Operations and Points it muſt be obſerved, *That if no Multiple (no not the leaſt of all) found in the left Rods, and the Plate, can be ſubſtracted from the foregoing Remains; then a Cypher* [0] *muſt be put under that Point for the*

the Quotum, the Remains being untouched, and abiding as before.

CAUTION II.

And if the aforeſaid Sum, to be taken away, cannot be taken from the Figures going before its Point, the ſmaller Multiples muſt be added, which the next upper Quotums in the Cubick Rod do ſhew in the Rods, whoſe Sum may be taken away therefrom.

Example of the Cubick Extraction.

Let 22022635627 be a Number given, whoſe Cube Root you deſire: Set down your Number, and point it, (beginning at 7, the laſt Figure towards the right Hand, and ſo under every third Figure) and draw two parallel Lines under it, and it will ſtand in this Manner;

22022635627
  ·   ·   ·   ·

Look in your Rod, for the Extracting the Cube Root, for the neareſt Cube Root of the Figures of your given Number, ſtanding before the firſt Point towards your left Hand, namely, for the neareſt Cube Root of the Number

leſs than 22, which you ſhall find to be 2, which ſet between the two Lines juſt under the firſt Point, and its Cube (which is 8) ſet under the Line, and ſubſtract it from the Figures above the Line, namely, from 22, and there will remain 14, which place orderly above, then will your Work ſtand thus, and the Work of your firſt Point finiſhed;

$$\begin{array}{l} 14 \\ 22022635627 \\ \;\cdot\;\;\cdot\;\;\cdot\;\;\cdot \\ \hline \;2 \\ \hline \;8 \end{array}$$

Secondly, For the finding of the Root belonging to the ſecond Prick, triple the Quotum, or Figure which is under the firſt Prick, (namely 2) and it is 6; find therefore a Rod which hath 6 at the Head thereof, and lay that Rod by the Side of your Cubick Rod towards the right Hand, then triple the Square of 2 (which is 4) and it makes 12, which, found among the Rods, place by the Side of the Cubick Rod towards the left Hand.

Then from the Rods which lie on the left Hand of the Cubick Rod, and the Cubick

Cubick Rod itſelf, find the neareſt leſſer Number than the Figures ſtanding before the ſecond Prick, namely, leſs than 14022, and in the ninth Place you ſhall find 11529, which write by itſelf, as in the Margin, and over 9, the laſt Figure towards the right Hand (drawing firſt a Line between) ſet its Quotum, and by it its Square 81, in the ſame Order as you find them ſtand in your Cubick Rod.

819
11529
6
48
16389

Then write under 1, its Multiple, which is ſhewed rightwards againſt 1 in the Cubick Rod, and is the ſingle Figure 6, and under 8 write the Multiple, that it ſhews rightward againſt 8 in the Cubick Rod, which is 48, and theſe three Multiples ſo written croſs-wiſe below the Line, and added together (as in the Margin) do produce 16389, which, becauſe they cannot be taken from the upper Figures ſtanding before the ſecond Point, namely, from 14022, the Number 9 (before taken) is to be rejected, as being too great, and inſtead of 819 (by the ſecond Caution) the next higher Notes in the Plate are to be taken, which are 648, and the Mul-

Multiples that theſe do ſhew, namely, the Octuple among the left Rods, which is 10112, and the Quadruple among the right Rods, which is 24, and the Sextuple among the right Rods, which is 36, being added croſs-wiſe (as in the Margin) do produce 13952, which ſubſtracted from 14022, (the Figures ſtanding before the ſecond Prick) there remains 70 for the Remainder of the ſecond Prick, and let there be taken for the Quotum of the ſecond Prick, the right-moſt of the choſen Figures 648, which is 8, which place under the ſecond Point between the Lines; ſo is the ſecond Figure of your Root found, and your Work will ſtand thus;

```
  648
-----
10112
   24
  36
-----
13952
```

```
    70
14
22022635627
•    •    •    •
---------------
 2   8
---------------
 8
13952
```

Thirdly,

Thirdly, Put the Triple of the precedent Quotums (*viz.* 28 between the Lines) which is 48, being taken out of the Rods, and put them on the right Side of the Cubick Rod, and get the Triple of the Square of the ſame 28, which may be found to be 2352, which take out of the Rods, and place on the left Side of the CubickRod; and of the Multiples on the left Hand Rods, and the ſimple ſingle Figures upon the Cubick Rod (the leaſt of which being 235201) there is none ſo little that may be ſubſtracted from the Figures belonging to the third Point, namely, from 70635: Therefore (by the firſt Caution) the Remains abiding, or continuing as they are, you muſt put a Cypher under the third Point, for the third Quotum belonging to the third Point: And thus the Operation of the third Point is accompliſhed, and the Work will ſtand as followeth;

$$\begin{array}{r} 28 \\ 28 \\ \hline 224 \\ 56 \\ \hline 784 \\ 3 \\ \hline 2325 \end{array}$$

```
    70
14
22022635627
 .   .   .   .
————————————
 2   8    0
————————————
 8
13952
```

Fourthly, Set the Triple of the foregoing Quotums (*viz.* 280) which is 840 on the right Hand, and the Triple of the Square of the same 280, which is 225200 on the left Hand, and the Cubick Rod between them; then, out of the leftmost Multiples, choose that which is next less than the Figures belonging to the fourth Point, namely, 7063 5627, which is this 70560027, which stands against 3 on the Tabulat; wherefore write this Number 70560027 upon Paper, in the Margin, with a Line over it, and set over the Line the

```
   280
   280
——————
 22400
  560
——————
 78400
     3
235200
```

	93
	70560027
	7560
	70635727

the Quotient 3, over its right-moſt Figure, and the Square of the ſaid Quotum 3, which is 9, leftward thereof, and the Noncuple found in the right Hand Rods, which is 7560, write under 9; let theſe two Multiples be added as in the Margin, and the Sum will be 70635617, which ſubſtracted from the Figures foregoing the fourth Prick, and there will nothing remain; therefore let the right-moſt of the Figures of 93, *viz.* 3, be placed under the fourth and laſt Point, for the fourth and laſt Quotum of the Root, and ſo the whole and perfect Cubick Root of the given Number 22022635627, is 2803, and, ſince nothing remained, it is a perfect Cubick Number. The like is to be done in other Numbers, but I ſhall forbear to give you any more Examples, there falling out in this all the Variety that at any Time may happen for the *General Rule*; and the two *Cautions* before premiſed are here made applicable to Practice; wherefore to this Treatiſe for the preſent I will put

F I N I S.

ERRATA:

Page 12, Line 25, for 3 *Degr.* read 31 d. 46 m.

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that point of the Equator must
necessarily be enlightened thro'
the shadow which becomes it.
To direct the person who makes use
of the Ring dial, let a Circle be
drawn upon paper, equal in
diameter to ye Aperture, which one
judges proper to give to the Bridge
the Length of that Aperture is equal
to our Arch of the Meridian of 47
degrees, to take in all ye declinations
of the sun; & ye Circle drawn, which has
ye Aperture for a diameter, represents
ye Ecliptic with its twelve Houses.
that Circle, therefore, is divided into
twelve equal parts, ye points, thereof
are joined two & two by parallel Lines,
which make Spaces, narrower
towards the Tropics, & wider towards
the Equinoxes, which serve for twelve
Months, are divided afterwards
into three times ~~t~~ ten days,

or into six times five, to suit, as near as possible, y^e position of the Cursor to the actual Declination. all these measu are carefully transferred on y^e two Edges of the Bridge. when this Instrument is intended for use, the Cursor is put to y^e Day of the Month, and the Suspension to the Latitude of the place: we turn, afterwards, th flat side of the Bridge, towards y^e Sun, & his Rays fall exactly on the Edge of the Equator, except on the days of the Equinoxes, when the Su turning round the brass Equator, as he does round y^e Celestial, can only cast the Shadow of the upper Edge, on that opposite to it, the Hour of 12 at Noon must also be excepted; because the Sun, shinin then on the brass Meridian, thro the shadow thereof upon the opposit Edge, where, when y^e Hour of 12 is marked. one may know, however,

hat it is Mid-day, by the Dial
aving no radiant point at all